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Commonwealth of Pennsylvania

WATER SUPPLY COMMISSION OF PENNSYLVANIA

Water Resources Inventory Report

PART VII

WATER POWER

ACT OF JULY 25, 1913

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WATER SUPPLY COMMISSION OF PENNSYLVANIA

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(Appointed December 1, 1915, vice Benjamin K. Focht, Resigned)

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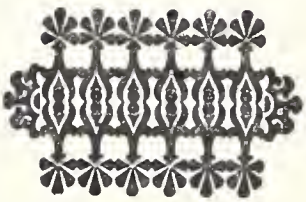

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LETTER OF TRANSMITTAL

Office of the Water Supply Commission,
Harrisburg, September 20, 1916.

His Excellency, the Governor of the Commonwealth of Pennsylvania:

The Members of the Senate and the House of Representatives of the Commonwealth of Pennsylvania:

Gentlemen: The Water Supply Commission of Pennsylvania respectfully submits herewith Part VII of the Water Resources Inventory Report, entitled "Water Power," which contains information concerning the history and present status of water power in Pennsylvania, including descriptions of the larger hydroelectric plants and all the important hydroelectric projects which are proposed for early development. This pamphlet also contains a statistical review of operating plants.

THE WATER SUPPLY COMMISSION OF PENNSYLVANIA,
THOMAS J. LYNCH, Secretary.

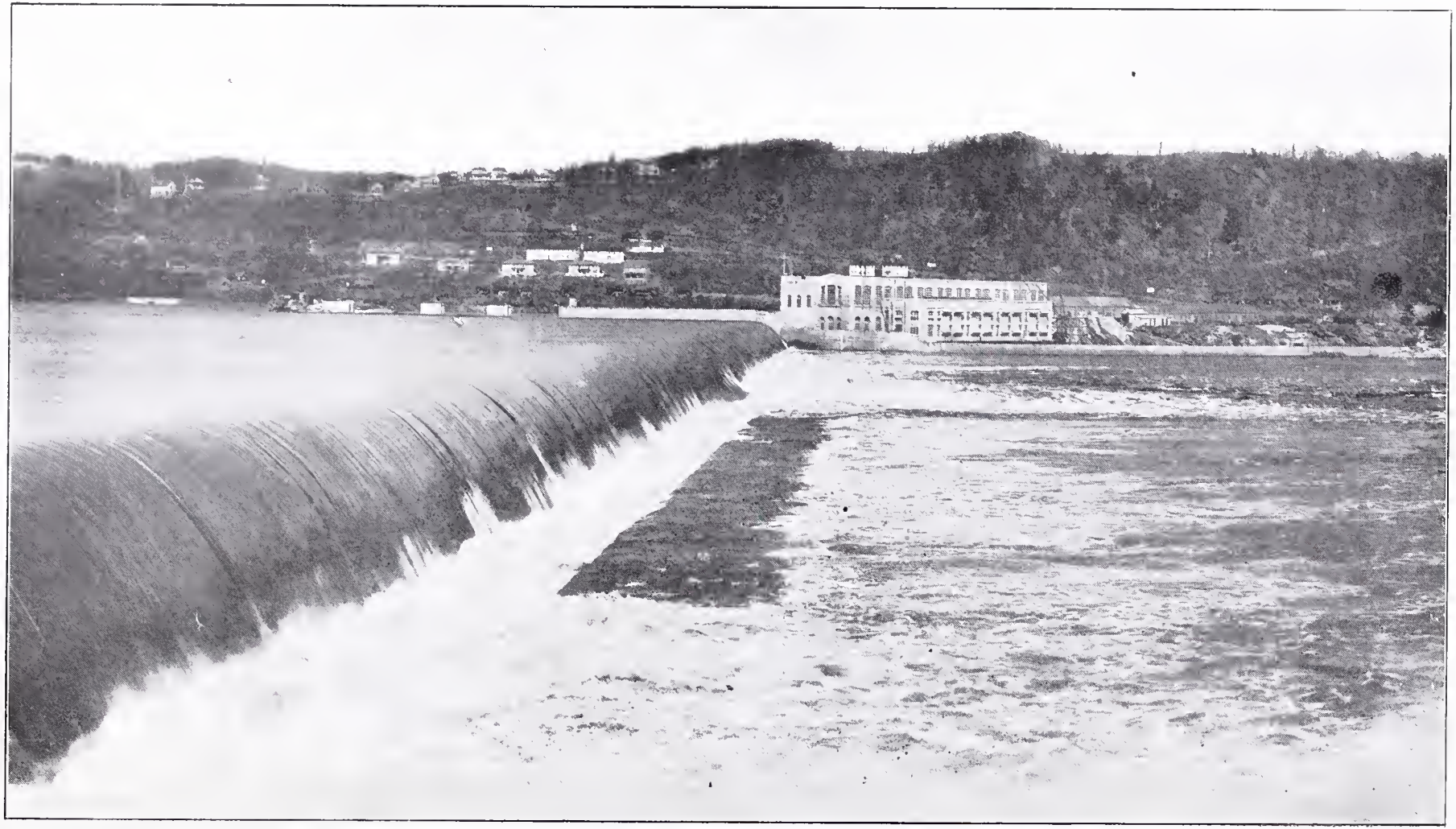

Fig. 1. Plant of Pennsylvania Water & Power Co., Susquehanna River at Holtwood

PART VII

WATER POWER

(The data herein contained were collected during the year 1914, and the conditions described were those then existing.)

INTRODUCTION

The use of water power conserves fuel and often encourages the utilization of water for other purposes, but unfavorable conditions have restricted its development and use. The power produced in the State is mainly obtained from combustion of fuels, and probably will continue so until the increasing scarcity of coal, or the augmented cost of production raises the price materially. The highest use of fuel is to furnish the heat needful to maintain life; and the term of man's existence may depend upon his care of the supply. Fuel is not reproductive and each day's consumption lessens the reserve. Already in some cases the production has begun to decline. The need of other sources of energy, though not immediate, is certain and should be prepared for by the utilization of all other available sources of energy and especially that of flowing water so generally accessible, but so meagerly applied.

Water power cannot be stored for future use like fuel, but offers the great advantages of permanence in supply and location. The early utilization of all practicable water powers is, therefore, a worthy aim; and Pennsylvania, whose importance depends largely upon her fuel fields and manufacturing industries, should encourage any development which lengthens the productive life of her fuel supply.

General Conditions:

The investigations of the United States Census Bureau indicate that the direct utilization of water as a source of energy for manufacturing plants is diminishing in Pennsylvania, while the use of fuel is rapidly increasing. In 1869, water power supplied 39 per cent of the power so used, while in 1909 it furnished 1.91 per cent. During those 40 years the capacity of water wheels directly employed in manufactures decreased from 141,982 to 55,194 horsepower, while in the same interval the capacity of steam engines increased from 221,986 to 2,541,117 horsepower. However, water

power is being more largely used in another field—that of the production of electrical energy. The Census figures show that the use of electric power in manufactures is growing and a corresponding portion of this energy comes from central stations driven by water. The extent to which this use of water power has developed in Pennsylvania is shown in Table No. 1.

TABLE No. 1. *Primary Power in Commercial and Municipal Central Electric Stations*

Year.	Horsepower of steam engines and turbines.	Per cent of total.	Horsepower of water wheels.	Per cent of total.	Horsepower of gas and oil engines.	Per cent of total.
1902,	166,739	95	6,988	4	1,783	1
1907,	264,205	87	30,863	10	7,469	3
1912,	465,968	76	132,293	21	17,733	3

The above indicates that the future field of water power development is that of commercial and municipal electric light and power. At present the total water power employed in manufactures and central stations is small compared with that produced by steam. The cost to the ultimate consumer of power generated by water must not exceed the cost of power produced from other sources in that locality. The bituminous and semi-bituminous coals occur in most of the western half of Pennsylvania, and the anthracite in the eastern central portion. The cheaper coals can be obtained near the mines at from $1.00 to $1.50 per ton—occasionally for less than $1.00—and power can be produced in high grade steam stations efficiently and cheaply; therefore, severe competition must be met by water power.

Irregularity in the flow of streams is another fundamental reason for the lack of water power development. Reference to the results of stream measurements as contained in the reports of the Water Supply Commission will illustrate this characteristic, while the typical hydrograph in Fig. 2, shows the extreme variations in flow which may be observed on almost any of our streams. Irregularity of flow compels hydroelectric plants to impound water or to use steam or other auxiliary power for providing service during a

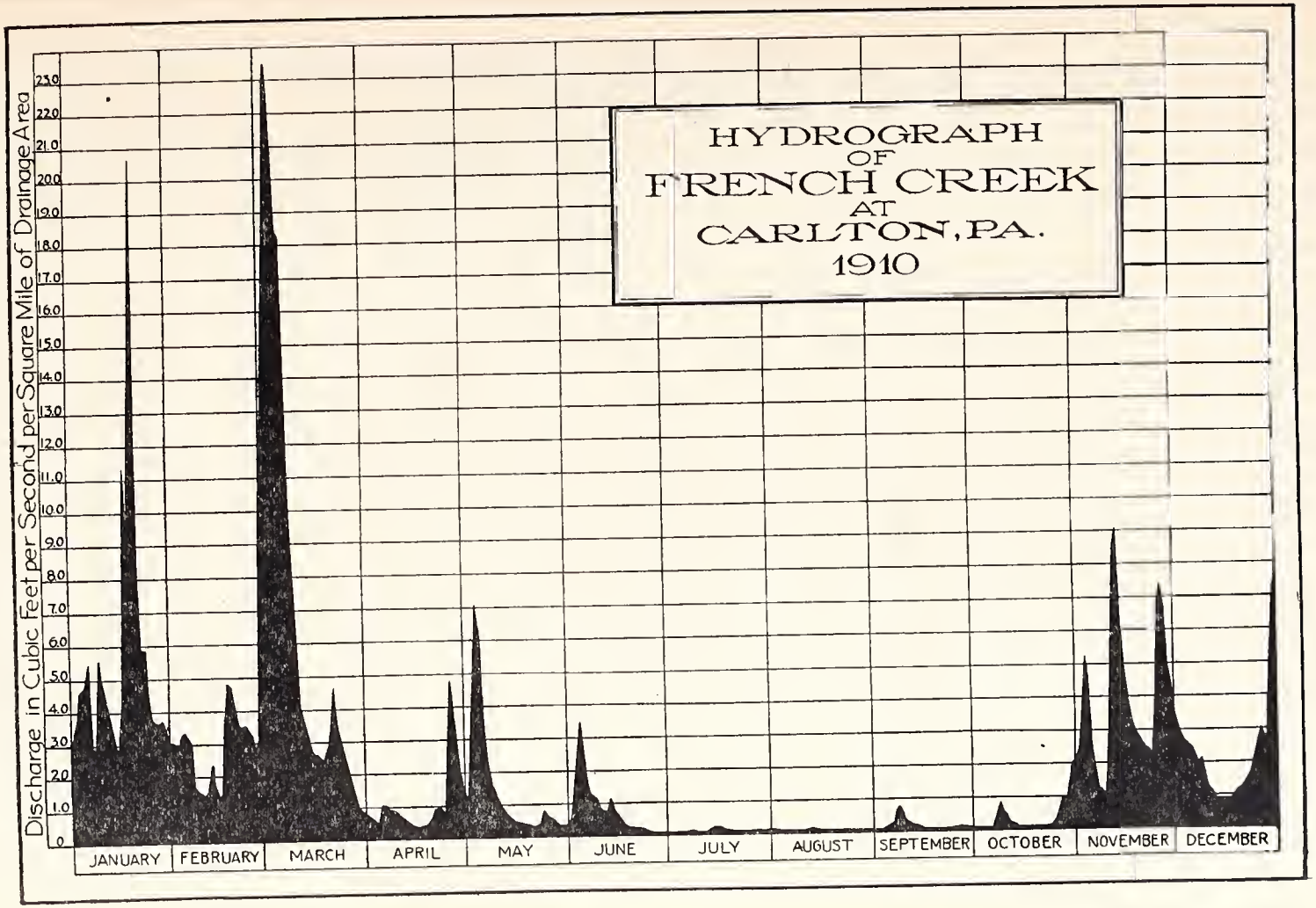
HYDROGRAPH
OF
FRENCH CREEK
AT
CARLTON, PA.
1910
Discharge in Cubic Feet per Second per Square Mile of Drainage Area
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

Fig. 2

portion of the year, and water power installations must carry additional capital and operation charges on such adjuncts or sell power at a reduced price without guarantee as to continuity of service. Independence of the use of fuel and of the irregularity of flow can be obtained only by the construction of enormous reservoirs, unless the water power installation is limited to use only low stream discharges.

Land values are generally high because Pennsylvania has reached an advanced stage of economic development; large water power operations often require the acquisition of much property and frequently involve the submergence of improvements, thus rendering many possible water power developments impracticable. These objections apply especially to the construction of storage reservoirs.

Railroads generally follow river valleys and their presence, with that of communities built along them, increases the difficulty of stream improvement. In many cases profitable development is made impossible or its limit fixed by existing railroads. Illustrations are seen in the Lehigh, the Juniata, the North Branch of the Susquehanna, the lower Youghiogheny and the Allegheny valleys, each traversed by one or more railroads. Had water power been developed prior to the introduction of the railroads, the latter would have accommodated themselves to the situation; but now the use of water power in such localities will not be feasible for many years, if ever. This is a reason for the early development of possible sites.

The laws relating to the development of water power in Pennsylvania are unsuited to present conditions, as the statutes affecting the construction of power plants were devised years ago to meet the development of small installations on minor streams. While jurisdiction over the granting of charters to water power companies has been entrusted to the Water Supply Commission, the General Assembly has not formulated a definite policy to govern the action of that body. The water laws of the State should keep pace with industrial progress, so that uncertainty as to the form which revision may take will not be a deterrent to development.

An increase in the use of water power for the generation of electric current has been noted; but some of the large installations in Pennsylvania have encountered financial vicissitudes before developing profitable operations, and receiverships and reorganizations have been experienced. A hydroelectric development is a business enterprise, and the cost of construction and operation should be such that all charges are exceeded by the income.

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The total capacity of hydroelectric plants in operation in Pennsylvania at the end of 1914 was about 173,000 hp., while charters have been granted in the last 10 years for 15 additional projects, 14

of which have a total capacity of 336,260 hp. These have been regarded as offering reasonable prospects of success, although not yet built. There are now on file with this Commission applications for incorporation representing an aggregate proposed capacity of 822,500 hp. An enormous aggregate of undeveloped power is available, but many potential developments are not feasible at this time, as their cost is too great to permit the profitable sale of power under competition with existing supplies of energy; in other words, some power physically possible is not economically available.

Early Developments:

In the early history of the State, water was the only source of power, and forges and bloomeries, grist mills and sawmills, operated by water power, were among the first industries established. Subsequently tanneries, paper mills, cotton and woolen mills utilized this form of energy. The earliest developments were in the eastern part of the State, the first probably being built by the Swedish settlers on Cobb's Creek, Delaware County, in 1643. Industrial centers, particularly certain localities in the Lehigh, Schuylkill and Beaver basins, grew up around good power sites, the mills and factories using the energy directly to drive machinery. The number of mills increased rapidly and reached a maximum about the time of the Civil War; since then they have diminished in number and importance.

The decrease in the direct use of water power is due to various causes, among which the concentration of the application of power is prominent. Many sawmills, formerly operated in the forest lands when lumber was extensively manufactured, are abandoned, and transportation of products by railroads to the large centers has reduced the necessity for local flour and grist mills. Cheapened coal has led to a preferential use of steam engines, while the introduction of gas and gasoline engines and electric motors is still another factor.

Present Tendencies:

The present tendency is to employ water power in the generation of electrical energy and distribute this to nearby and more distant points of consumption. The Census data, quoted at the beginning of the chapter, show a high rate of increase in the generation of hydroelectric power, more than one-half of which, however, is due to the single plant at Holtwood on the Lower Susquehanna River.

The majority of the hydroelectric plants utilize the flow of streams without much regulation, and are compelled to depend upon auxiliary

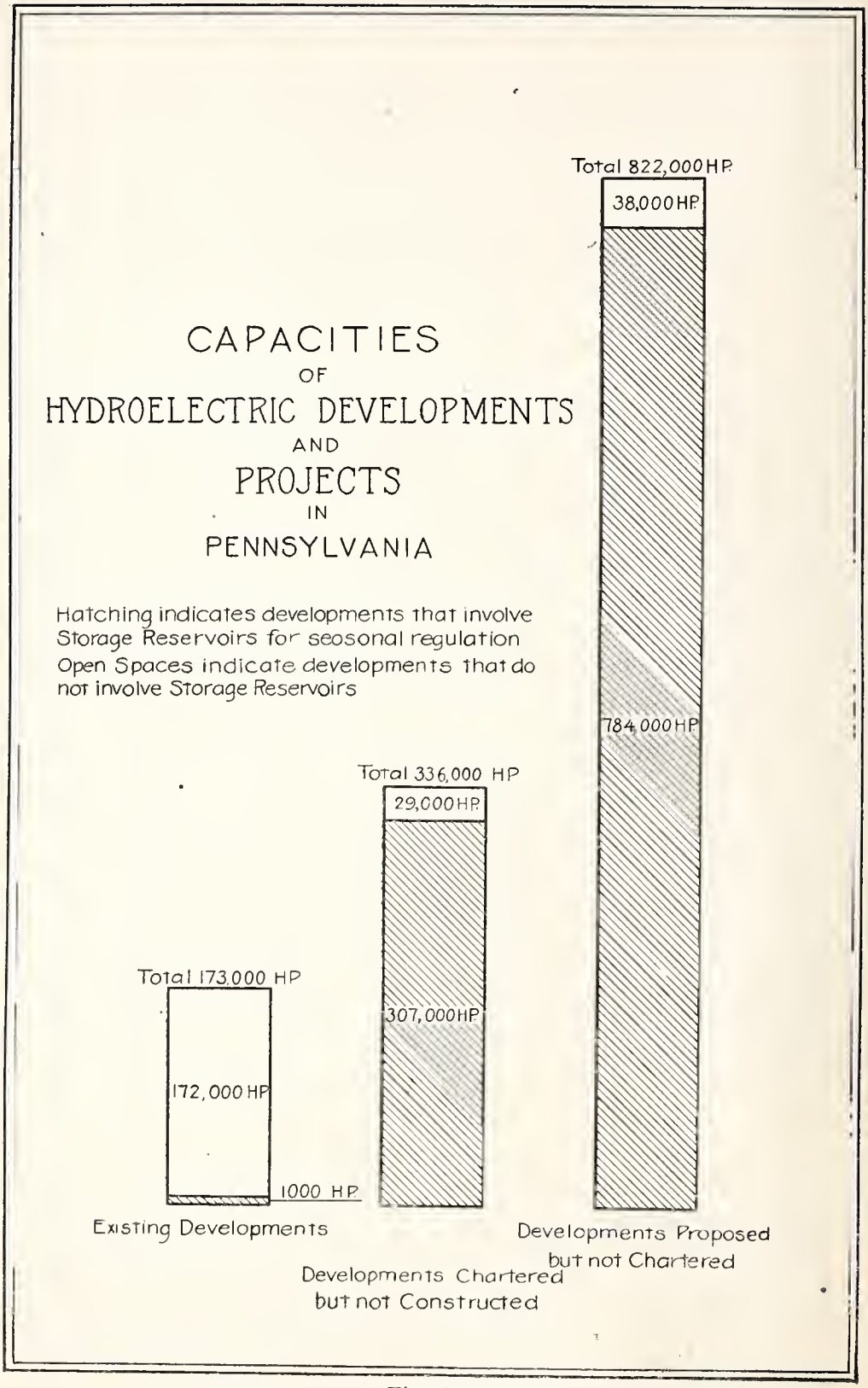

CAPACITIES
OF
HYDROELECTRIC DEVELOPMENTS
AND
PROJECTS
IN
PENNSYLVANIA
Hatching indicates developments that involve Storage Reservoirs for seasonal regulation
Open Spaces indicate developments that do not involve Storage Reservoirs
Total 822,000 HP
38,000 HP
784,000 HP
Total 336,000 HP
29,000 HP
307,000 HP
Total 173,000 HP
172,000 HP
1000 HP
Existing Developments
Developments Chartered but not Constructed
Developments Proposed but not Chartered

Fig. 3

power to maintain service during periods of water deficiency. Some have complementary steam or gas engine stations; others purchase power from steam stations; while others sell part of their product as secondary power, (i. e., without guarantee as to continuity of service), to distributing companies operating steam-driven stations.

The tendency revealed by a study of the pending and proposed projects is in the direction of regulation by storage reservoirs. Only one such development has been completed and has been in successful operation for several years. Ninety-four per cent of 1,158,760 hp., covered by contemplated projects, are based on storage regulation. (See diagram, Fig. 3).

Market Conditions:

The industrial development of Pennsylvania, which was due primarily to the utilization of water power, has, however, been encouraged by vast deposits of coal, oil, gas and other minerals, and the creation of excellent transportation facilities, leading to the concentration of industry in centers which would form the principal markets for hydroelectric power. The experience of existing hydroelectric plants shows that their markets for power have been usually developed in co-operation with new or existing steam stations, and in some cases their output is wholesaled to companies owning the latter.

Competition:

The cost of power at steam stations of the best type is not greatly in excess of that at hydroelectric plants in Pennsylvania, and projected plants must anticipate severely competitive conditions, especially in the regions adjacent to cheap fuels. At some anthracite mines, where the use of fine coal has been found practicable, the fuel item is represented chiefly by the cost of handling the material from bank to boiler, which, with the recent development of the steam turbine and other improvements in steam and electric machinery, enables power to be sold at a low figure within reasonable transmission distances of the mines.

Public Benefits:

In considering conditions affecting the use of the streams for power, the ultimate benefits to the public from their development must be recognized, for all such power utilized represents conservation of the stores of fuel. Most complete utilization is obtained through storage reservoirs, which also provide a measure of pro-

tection from floods and an increase in the low water flow of the streams. The latter effect will improve sanitary conditions, maintain adequate domestic and manufacturing water supplies and facilitate navigation.

Another important factor favoring the use of water power is the independence of disturbed industrial conditions due to strikes and other labor troubles.

WATER POWER CORPORATIONS

Water power corporations in Pennsylvania are of two classes: (1) those incorporated for ".....the supply, storage and transportation of water and water power for commercial and manufacturing purposes," (Act of April 29, 1874, P. L. 73, Section 2, Corporations for Profit, clause 9, as amended by Act of May 16, 1889, P. L. 226); (2) those formed ".....for the storage, transportation and furnishing of water ..... for manufacturing and other purposes and for the creation, establishing, furnishing and transmission for public use of water power therefrom: .....," (Act of April 29, 1874, P. L. 73, Section 2, Corporations for Profit, clause 18, as amended by Act of June 3, 1911, P. L. 635). Since May 4, 1905, applications for incorporation of both classes must be approved by the Water Supply Commission.

All companies incorporated prior to 1874 were created by special Act of Assembly, and were generally for the direct mechanical utilization of water power. Subsequent to the passage of the Act of 1874, all applications required executive approval, provided that the corporations were formed for one of the purposes specified in that act. Most of the charters granted since 1874, were obtained for the generation of electric power. Of the 73 water power companies of record, incorporated previous to the establishment of the Water Supply Commission, as listed in Table No. 9, on pages 53 and 54, (Appendix A), only seven hydroelectric plants have been built, but the Pennsylvania Water & Power Co., (formerly the McCall Ferry Power Co.), controls, through merger, purchase or stock ownership, 15 charters in various townships. Three companies, the Ellwood Power Co., The Monroe County Water Power & Supply Co., and the Juniata Water & Water Power Co., constructed plants which have been sold to other corporations.

The incorporation of water companies has been subject to the approval of the Water Supply Commission since its establishment in 1905, and no charter may be granted to a water power corporation, since June 7, 1907, unless its application specifies the name of the stream to be used and the points between which power is to be developed. The water power charters granted between May 4, 1905, and December 31, 1914, are listed in Table No. 10, on pages 55 and 56, (Appendix A).

Of the 52 companies which have received charters, 10 are operating six developments; four have been consolidated by merger into one of the above operating companies; three, representing two projects, have been dissolved; and 35, representing 12 developments, are not operating, although one started construction, but was forced to abandon work on account of financial difficulties. Of the 10 which are operating, one, covering a single project of three plants, built prior to the granting of charters, is a holding company for four others, all of which may later be consolidated by a merger. Of the 35 non-operating companies, 22 have been merged into three consolidations; and one represents a lapsed charter obtained in connection with one of the operating developments. In all, 26 companies have been combined in four mergers covering four projects, one of which was operating prior to incorporation. Classified by projects, the 52 charters represent 20 projects, of which two covered works previously built and four have been constructed since incorporation. Table No. 11, page 57, (Appendix A), shows the capacities of the hydroelectric developments now operating under water power charters, and Table No. 12, page 57, (Appendix A), gives the mergers of water power companies, insofar as the records show.

Another class of companies developing water power are those incorporated for "..... the supply of light, heat and power by means of electricity .....," (Act of April 29, 1874, P. L. 73, Section 2, Corporations for Profit, clause 11, as amended May 8, 1889, P. L. 136). Such corporations exist primarily as distributing companies and possess the same rights and privileges with reference to the streams as individuals; but they have certain powers as to rights of way for pole lines, and may be organized in connection with water power companies to distribute the power generated.

Table No. 13, page 58, (Appendix A), lists 34 companies of this class, operating 38 water power plants, of a total capacity of 12,687 hp., for the partial or complete generation of current. The average capacity per plant is 334 hp., only 5 exceeding 500 hp., while 12 are rated under 100 hp. These companies generally supply small towns with light and power and have few long transmission lines or large customers.

HYDROELECTRIC PLANTS IN OPERATION

The Inventory Act directed the Commission to collect all pertinent data concerning the water powers of the State, and a logical procedure required that a study of developed water powers should precede that of those undeveloped, to disclose the facts and tendencies determined by past experience. Since the principal future use of water power is undoubtedly to be the production of electrical energy, a study of the hydroelectric plants was made to ascertain their physical and economic features, their opportunities and limitations, and other pertinent facts and principles. The study was to be accompanied by a brief summary of the other uses of water power. In this investigation, all plants of importance have been visited by a representative of the Commission, to examine their physical features and to determine the cost of construction and of power production. All water power companies which generate current for sale to the public or for electric railways are included.

The distribution of such plants is shown on the map, Fig. 4, on which the State is divided into sub-drainage basins for convenience in discussion and classification, using the same divisions as in the study of water supplies, (Part VI, Water Resources Inventory Report). The map shows graphically the locations and capacities of the stations, and the plants are also listed in Table No. 5, page 28, under the same classification, to show the essential physical features of each. Detailed descriptions appear on pages 59 to 92, (Appendix B), arranged to follow each large stream from the headwaters to the mouth, noting the larger plants as they exist, either on the stream or on its tributaries. Some facts developed by analysis of the essential features are summarized below.

1. Character of Developments:

The preponderance of low head developments is exhibited in the following table which shows that 61 per cent of the developments are of heads less than 20 feet, while 84 per cent are of heads less than 30 feet.

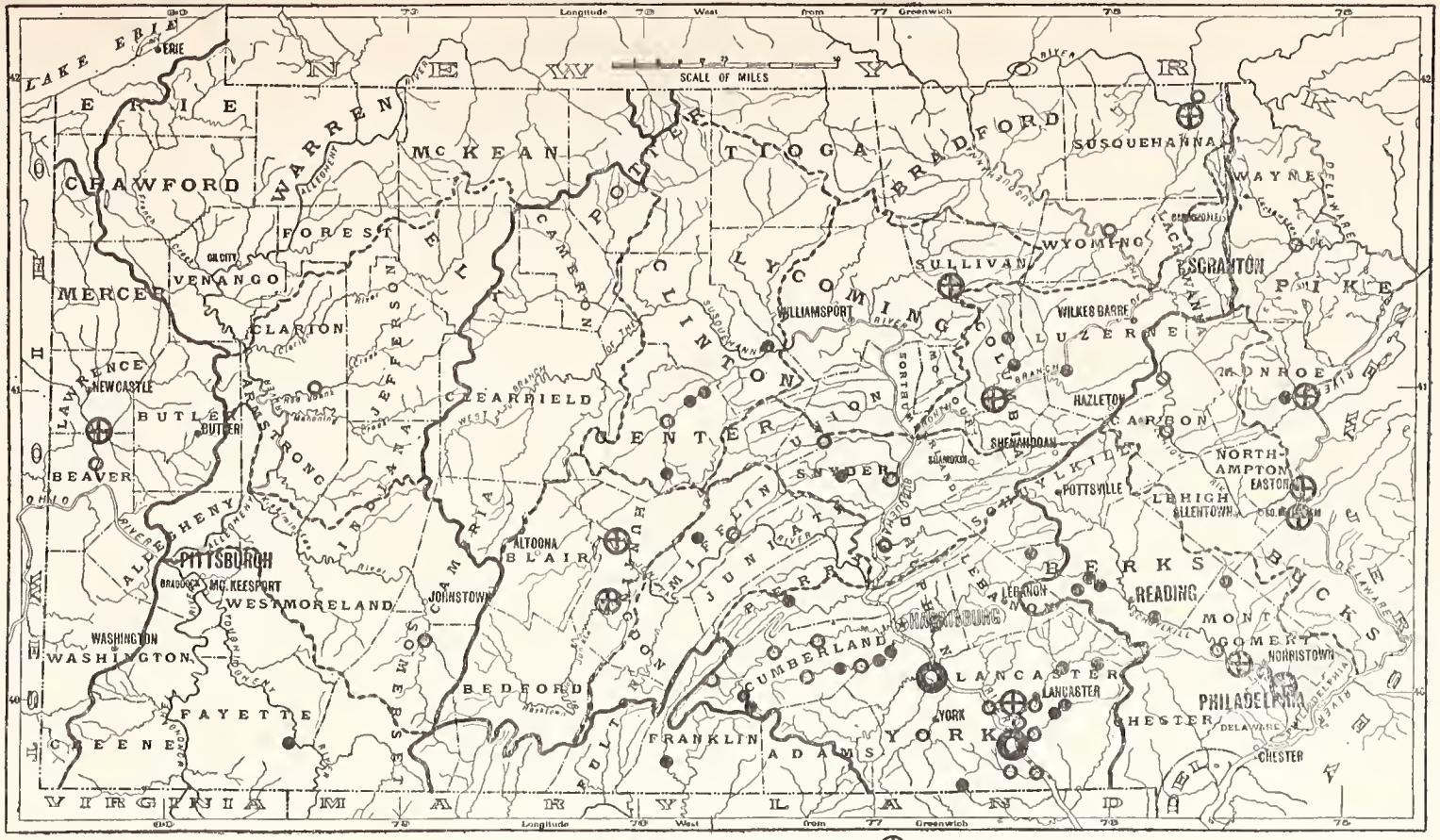


Fig. 4. Map showing distribution of hydroelectric plants

TABLE No. 2

Head in Feet.	Number of plants.	Per cent of total.	Total capacity in hp.	Per cent of total.
Less than 10,	19	27.2	3,921	2.27
10 to 20,	24	34.3	6,599	3.82
20 to 30,	16	22.8	37,239	21.54
30 to 40,	5	7.1	5,550	3.21
40 to 50,	1	1.4	500	0.29
50 to 100,	2	2.9	118,030	68.27
Over 100,	3	4.3	1,033	0.60
Total,	70	100.0	172,872	100.00

Only 3 of the 70 plants use heads of 100 feet or more, which might be taken as showing a scarcity of high head sites in Pennsylvania, but it is probable that available ones are more numerous than this proportion indicates. As the benefits of storage reservoirs are generally proportionate to the head developed, regulated flow can be utilized economically only in a development involving high head or a series of low ones. The absence of storage reservoirs, with the consequent lack of regulation, requires the majority of developments to rely upon using large quantities of water through the greater portion of the year and auxiliary power during times of deficient flow.

Three plants have overshot wheels which can be used under moderate heads and have a high efficiency under a wide range of flow. Two small plants employ water wheels of the impulse type, especially adapted to high heads. The remaining plants, 65 in number, utilize turbines.

2. *Use and Ownership*:

The principal use of the power generated is the supply of electric light and power to the public, in many cases through separate distributing corporations. Five plants supply electric railways primarily, and others carry an electric railway load as a part of their business. Three plants are used by municipalities, one lighting streets and public buildings only, and the other two supplying light and power to the public.

The following is a classification of water power development by ownership:

TABLE No. 3

Classification.	Number of plants.	Per cent of total.	Total capacity in hp.	Per cent of total.
Water power companies,	14	20.0	157,315	91.00
Municipalities,	3	4.3	525	0.30
Individuals or partnerships,	12	17.1	829	0.48
Electric distributing companies,	38	54.3	12,687	7.34
Electric railway company,	1	1.4	320	0.19
Other corporations,	2	2.9	1,196	0.69
Total,	70	100.0	172,872	100.00

The majority of these plants are owned and operated by electric distributing companies.

3. Distribution of Plants:

The following table prepared from Fig. 4, shows the distribution by drainage basins of the 70 plants listed, together with the total horsepower capacity in each basin:

TABLE No. 4

Basin.	Number of plants.	Per cent of total.	Aggregate capacity of plants in hp.	Per cent of total.
State as a whole,	70	100.0	172,872	100.00
Delaware Basin,	16	22.9	9,685	5.60
Potomac Basin,	1	1.4	35	0.02
Ohio Basin,	5	7.1	2,320	1.34
Susquehanna Basin,	48	68.6	160,832	93.04
of which the Lower Main Susquehanna Sub-basin has,	27	38.6	147,982	85.60

The developments in the Delaware Basin have been largely subsidiary to navigation of the Lehigh and Schuylkill rivers, as 9 of the 16 plants listed obtain water from the canal systems of the Lehigh Coal & Navigation Co. and the Schuylkill Navigation Co. These nine plants have an aggregate capacity of 7,720 hp., or 80 per cent of the total of 9,685 in the entire drainage area.

In order to increase their income the navigation companies now lease water to power users. It is probable that most of this power

would not be developed were it not for the prior existence of the canals, and the reduced demands of water for lockages, due to diminished navigation.

The small amount of development in the Ohio Basin is significant, as this area includes about one-third of the State. The Pittsburgh district is perhaps the largest power market in Pennsylvania, principally because of the extensive development of iron, steel and related industries, but only 2,320 hp. are developed by hydroelectric plants in all that portion of the Ohio Basin lying within the State. Water power was utilized mechanically upon the Beaver River prior to the development of the steel industry, but has somewhat diminished during the past few years. The prevalence of low priced fuel has discouraged development of water power in this region.

The comparatively extensive developments of the Lower Main Susquehanna Sub-basin are due in part to the absence of hampering railroad lines along the stream, but more largely to the relatively high price of coal in this district, which is so far from the mines as to make freight a material portion of the cost. The smaller plants in this basin are situated on tributaries of the Susquehanna, such as the Yellow Breeches, Conestoga, Conodoguinet and Pequea creeks, all of which traverse areas largely underlaid by limestone and exhibit a low water flow well above the average. The major portion of developed water power is in two plants on the main stream, which has a mean annual flow of approximately 40,000 second-feet; these plants, aggregating 142,500 hp., are designed to utilize large volumes of water under moderate heads, and future plants on the river would be of a similar type.

The rich agricultural region of Cumberland, York and Lancaster counties is extensively cultivated and contains many prosperous cities and towns which offer attractive markets for power. The cities of York, Lancaster, Harrisburg and Baltimore are served with hydroelectric power, and the smaller towns, as Carlisle, Shippensburg, Mercersburg, Hummelstown and Strasburg also offer markets for electrical energy.

The preponderance of hydraulic development in the Lower Main Susquehanna Sub-basin is due to the following causes:

1. The comparatively high price of coal.
2. Regularity of flow of the principal tributaries.
3. Availability of large quantities of water in the Susquehanna River during most of the year.
4. Opportunities for limited development without excessive railroad changes.
5. Large markets for power within reasonable transmission distances.

4. Use of Auxiliary Power:

Eighteen plants, with a total capacity of 3,042 hp., supply a guaranteed service without auxiliary power. Five plants, aggregating 4,990 hp., sell current in bulk to distributing companies without guarantee as to the continuity of service; that is, they sell only secondary power and receive their compensation at a flat rate per kilowatt-hour for power delivered, without fines or rebates for shortages or interruption of service. The distributing company must, therefore, maintain sufficient capacity to supply power when the water station cannot deliver it.

In 47 plants, reliance is placed on auxiliary power; either the company operating the hydroelectric station has a steam plant or else buys steam-generated power, when needed, from other producers. Combinations of the above arrangements are also employed.

It is difficult to determine the proportion of hydraulic power which may be regarded as primary, that is, power whose continuity can be guaranteed; but the concentration of the bulk of capacity in a few large plants permits a fair approximation. The minimum flow of the streams utilized by the four principal developments is sufficient to produce 18,600 continuous horsepower at 80 per cent efficiency. As these installations represent 87 per cent of the total developed capacity in the State, the total continuous primary power available probably exceeds 20,000 hp. However, daily flow may be regulated by pondage to produce twice this amount under a load factor of 50 per cent. In other words, about one-fourth of the installed capacity can be relied upon for primary power; the remainder must be supplemented by auxiliary plants to maintain service. Variation in the amount of pondage and the nature of the load may, in any case, establish a different proportion.

Notwithstanding the fact that three-fourths or more of the hydraulic installation must be supplemented by steam during certain periods, the total energy produced is chiefly hydroelectric. In the systems of combined steam and water service which have been examined in Pennsylvania, the steam-made energy is from 15 per cent to 20 per cent of the total supplied in an average year. This proportion is exceeded in some cases where the hydraulic installation is not great enough to handle the maximum load unaided. Smaller proportions of auxiliary energy are recorded in plants which sell most of their output as secondary power and whose dependence upon auxiliary energy is more accurately described as emergency power. In the typical case, the yearly fuel expense is small compared with the capital charges on the steam plant.

5. Characteristics of Small Plants:

Fig. 4, page 20, shows that of 56 plants, comprising 80 per cent of the total, none exceeds 500 hp. capacity. Thirty-five represent adaptations of old mills or mill sites which in most cases had been abandoned, resulting in a depreciation of the property. The purchase of dam, races, water rights, etc., was effected at low cost, and some slight modifications of machinery permitted the hydroelectric plant to be established at small expense.

A characteristic of small plants is their prevalence on limestone streams, 26, or nearly one-half, being so located. This is largely due to the high rates of flow which these streams maintain during dry seasons.

Where local markets are available many small plants are successfully operated, but their aggregate capacity is small and the total effect in reducing coal consumption is almost negligible. The public benefits dwelt upon in this chapter are to be obtained from the large development of power rather than by additional small plants.

6. Cost Data:

The investigation of hydraulic plants offered opportunity to obtain useful and interesting data concerning the cost of construction and operation. The total actual cost of installing the hydroelectric plants is estimated at $27,350,000, excluding distributing systems and auxiliary equipment, or an average cost per horsepower of $158.00. In view of the fact that the installation costs were largely estimated from meager data, it is deemed unwise to give a classification of the detailed results. These figures are on file in the office of the Water Supply Commission and may be obtained upon application.

In 1913, the total power produced was approximately 344,600,000 kw.-hrs., or 462,000,000 hp.-hrs. This figure was obtained from the records of the companies, where available, and is estimated for the balance. As a rule the larger plants meter their switchboard output while the smaller ones do not, and the figures above, though not complete, are, however, fairly reliable.

Effort was also made to determine the cost of hydroelectric power at the switchboard. Sometimes this could be obtained with accuracy, but in most cases it was estimated, and included cost of operation, interest on securities, or upon actual cost when known, deprecia-

tion at from 1 per cent to 5 per cent according to the nature of the plant, and overhead charges. The results are shown on the curves of Fig. 5.

In stations greater than 1,000 hp., the production cost is low and diminishes as the size of the plant increases. In smaller stations, as the size diminishes, the cost rises rapidly, due chiefly to the high proportion of expense for wages and the low load factor (Load factor is the ratio of the average load to the maximum load during any period in which a cycle of events takes place). The small lighting plants, with loads concentrated chiefly within a few hours, operate at a smaller factor than larger plants carrying a heavy power load during the day and a lighting load all night. This illustrates the economy of large plants, which is independent of the source of energy.

The cost of production at the generating station is only a part of the total cost of power at the point of delivery to the consumer. The transmission and distributing systems involve investment charges, administration and operating expenses, as well as losses of power, while the influence of load factor is also important. The station load is a composite of the various demands, and the management strives for a combination that will provide the highest possible load factor.

The cost shown by the curves applies to power of which only part can be regarded as primary. The total cost of power to the distributing company includes the charges for maintaining and operating the auxiliary, not here included, which may add materially to the total. However, should developments be restricted to a capacity corresponding to the minimum stream flow, few works would be built, as the proportion of output to cost of construction would be too low to make operation profitable. Streams developed to a far greater capacity than the minimum flow have ample water during most of the year. The minimum run-off of the streams is about 0.1 second-foot per square mile, the mean run-off being generally from 1.5 to 2.0 second-feet per square mile. The economic limit, to which a stream should be developed, is an individual engineering problem, requiring elaborate calculation and study.

7. *Conclusion*:

Dependable water power service has generally been obtained with auxiliary steam power, and, therefore, with some duplication of generating capacity. If the cost of the water power plant enables the producing company to carry operating, investment and overhead

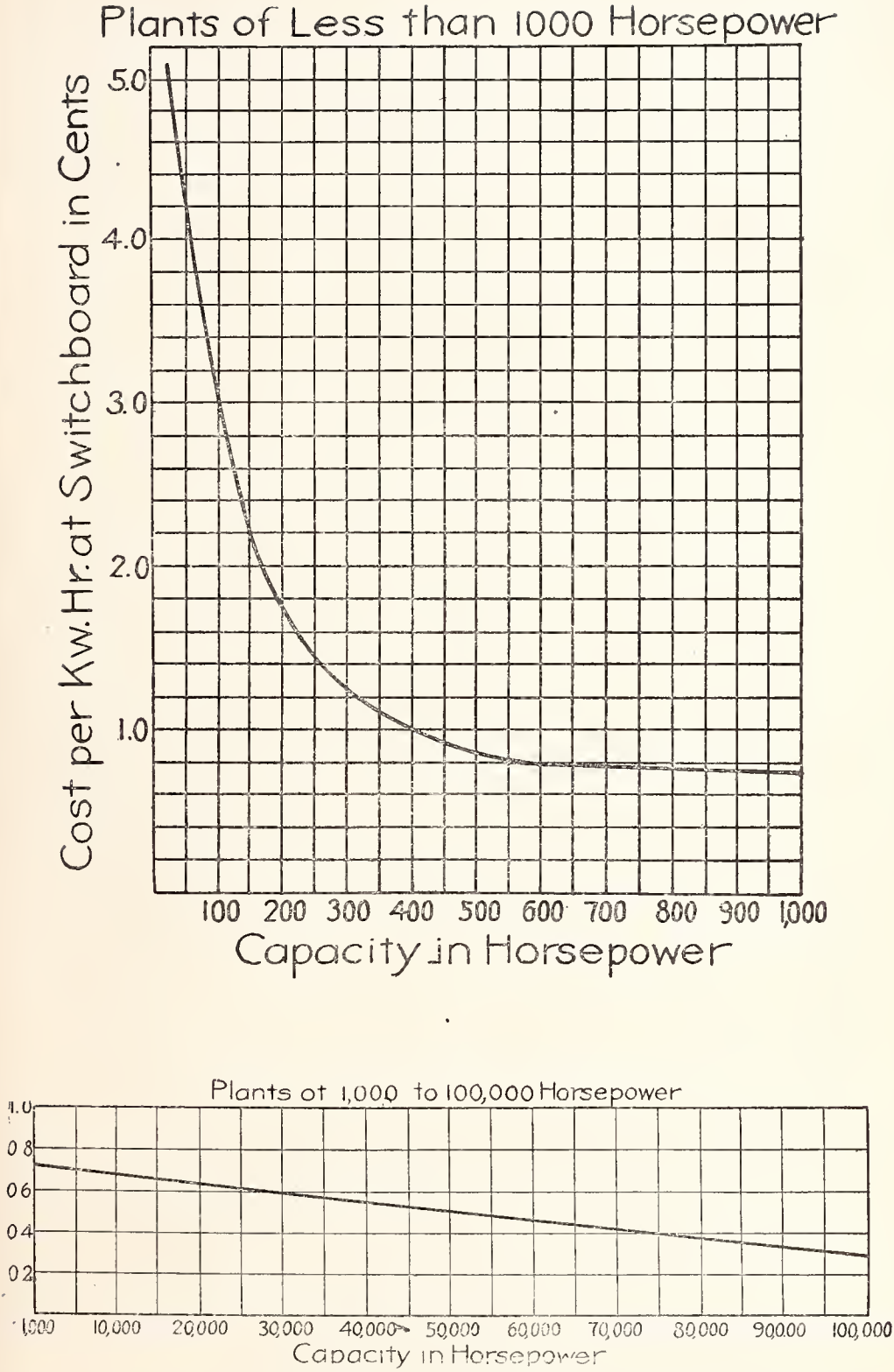


Fig. 5. Curves showing cost of production in hydroelectric plants

charges on combined water and steam stations at less than similar charges on a steam plant, then the water power has been profitable. The capital charges of the larger works have frequently been too heavy in the beginning, with consequent reorganization and reduction of the investment by eliminating a portion of the securities. Conservative methods of financing water power developments are essential to success.

TABLE No. 5. *Characteristics*

Name of Owner.	Stream.	Location.	Drainage area—sq. mi.	Capacity—hp.	Head—feet.
UPPER DELAWARE.					
Paupaek Electric Co.,	Wallenpaupaek Creek,	Hawley,	230	400	32
W. C. Peters & W. H. Shaffer,	Pocono Creek,	Stroudsburg,	32	35	17
Central Broadheads Power Co.,	Brodheads Creek,	Below Stroudsburg,	400	1,250	23
				1,685	
MIDDLE DELAWARE.					
W. J. Hauser,	Lehigh River (canal),	White Haven,	315	150	26
Carbon Transit Co.,	Lehigh River (canal),	Mauch Chunk,	525	320	11
Easton Gas Co.,	Lehigh River (canal),	Easton,	1,300	1,400	18
Clymer Power Co.,	Delaware River (Lehigh canal).	Raubsville,	1,370	1,100	32 16
				2,970	
LOWER DELAWARE.					
Womelsdorf Boro.,	Tulpehocken Creek,	Near Womelsdorf,	64	100	12
H. Kalbach,	Tulpehocken Creek,	Near Bernville,	130	60	8
H. Kalbach,	Tulpehocken Creek,	Near Bernville,	135	40	6
Birdsboro Electric Co.,	Schuylkill River (canal).	Birdsboro,	900	100	35
Phila. Suburban Gas & Electric Co.,	Schuylkill River (canal).	Cromby,	1,140	500	17
Phoenix Water Power Co.,	Schuylkill River (canal).	Phoenixville,	1,148	1,125	11
James Miller,	East Swamp Creek,	Sumneytown,	37	80	22
Norristown Boro. (Samuel Kent),	Schuylkill River (canal).	Norristown,	1,775	225	10
Phila. Hydro Electric Co.,	Schuylkill River (canal).	Manayunk,	1,825	2,800	23
				5,030	
UPPER NORTH BRANCH.					
Susquehanna County Light	Susquehanna River,	Lanesboro,	2,003	300	6
& Power Co.,	Susquehanna River,	Susquehanna,	2,024	800	9
Tunkhannock Electric Co.,	Tunkhannock Creek,	Tunkhannock,	400	200	10
				1,300	
LOWER NORTH BRANCH.					
Heller Milling Co.,	Big Wapwallopen Creek.	Wapwallopen,	60	73	26
Benton Electric Co.,	Fishing Creek,	Benton,	67	87	16
J. W. Conner,	Fishing Creek,	Orangeville,	230	70	11
Columbia & Montour Electric Co.,	Fishing Creek,	Near Bloomsburg,	300	710	29
				940	
MIDDLE WEST BRANCH.					
Boalsburg Electric Co.,	Galbraith Gap Run,	Boalsburg,	4	34	170
State Center Electric Co.,	Spring Creek,	Milesburg,	146	200	11
Centre Electric Co.,	Bald Eagle Creek,	Howard,	520	100	9
Long Electric Co.,	Lick Run,	Howard,	13	66	26
John Rich & Bros.,	Chatham Run,	Woolrich,	10	30	100
				430	

of Hydroelectric Plants

Wheels.		Generators.				Auxiliary Plants.	
No.	Type.	No.	Capacity—kw.	AC or DC.	Make.	Capacity.	Number and Character of Units.
2	23-in. Trump, ..	1	175	AC	Westinghouse,	450 hp., ...	Two steam engines with generators.
1	18-in. - - -	1	20	DC	.....	None.	
1	42-in. single runner Smith.	1	200	AC	Stanley, ...	.....	Steam plant of Pennsylvania Utilities Co.
1	42-in. double runner Smith.	1	450	AC	Stanley,		
1	27-in. Smith, ...	1	125	AC	S. K. C., ...	None.	
2	51-in. Smith, ...	1	100	DC	.....	.....	Other steam plants of company.
		1	66	DC			
2	60-in. double runner Smith.	2	500	AC	General Electric.	.....	Plant of Pennsylvania Utilities Co.
2	36-in. double runner Smith.	1	500	AC	National, ...	.....	Steam plant of P. & E. Transit Co.
		1	250	AC	National,		
1	Risdon-Alcott, ..	1	75	AC	Westinghouse,	.....	Auxiliary power bought from steam station.
1	45-in., ...	1	50	AC	General Electric.	None.	
1	.....	1	30	AC	General Electric.	None.	
1	18-in. Smith, ...	1	75	AC	General Electric.	100 hp., ...	Four valve steam engine.
1	45-in. double runner Smith-McCormick.	1	200	AC	Westinghouse,	.....	Other steam stations of company.
1	36-in double runner Smith-McCormick.	1	150	AC	Westinghouse,		
3	69-in. Smith, ...	3	250	AC	General Electric.	.....	This plant is auxiliary to steam plant.
1	.....	1	80	AC	.....	40 hp., ...	Gasoline engine.
2	56-in., ...	1	200	AC	.....	.....	Steam station of borough.
4	33-in. double runner Smith.	4	400	AC	Westinghouse,	.....	Power sold as secondary.
2	61-in. Trump, ..	1	200	AC	General Electric	600 kw., ...	Steam turbine.
3	52-in. Trump, ..	1	650	AC	General Electric	500 hp., ...	Corliss engine.
1	56-in. Trump, ..	...	.....	.....			
1	36-in., ...	1	60	.....	Westinghouse,	125 hp., ...	Steam engine.
1	48-in., ...	1	100	AC			
1	20-ft. Overshot,	1	27	DC	.....	None.	
1	Sampson, ...	1	75	AC	Warren, ...	80 hp., ...	Slide valve engine.
1	36-in., ...	1	75	AC	Crocker-Wheeler.	None.	
2	24-in S. B.-S. V.,	2	189	AC	Westinghouse,	.....	Other steam stations of company.
1	36-in. Smith, ...	1	225	DC			
1	Pelton, ...	1	30	AC	.....	None.	
1	35-in. Trump, ..	1	200	AC	Allis - Chalmers.	750 kw., ...	Steam engines.
1	44-in. Trump, ..	...	.....	.....			
2	9-ft. diam., ...	1	50	AC	General Electric.	None.	
1	24-ft. Overshot,	1	17	DC	.....	None.	
1	Trump, ...	1	25	DC	.....	150 hp., ...	Steam engine.

TABLE No. 5

Name of Owner.	Stream.	Location.	Drainage area—sq. mi.	Capacity—hp.	Head—feet.
LOWER WEST BRANCH.					
Eaglesmere Light Co., ...	Trout Run, ...	Near Muncy Valley, ..	3	924	502
MIDDLE MAIN SUSQUEHANNA.					
Mifflinburg Boro., ...	Penn's Creek, ...	Near Swengel, ...	306	200	12
Middleburg Light, Heat & Power Co., ...	Middle Creek, ...	Middleburg, ...	125	60	8
Northumberland County Gas & Electric Co., ...	Middle Creek, ...	Near Selinsgrove, ...	162	400	20
Millersburg Electric Light, Heat & Power Co., ...	Wiconisco Creek, ...	Millersburg, ...	98	160	12
				820	
UPPER JUNIATA.					
Pennsylvania Hydro-Electric Co., ...	Frankstown Branch,..	Warrior Ridge, ...	840	4,000	27
Raystown Water Power Co. (The), ...	Raystown Branch, ..	Near Huntingdon, ...	1,005	3,900	34
				7,900	
LOWER JUNIATA.					
Belleville Electric Co. (The),	Kishacoquillas Creek,	Belleville, ...	40	36	10
Yeagertown Water Power Co., ...	Kishacoquillas Creek,	Yeagertown, ...	185	500	20
				536	
LOWER MAIN SUSQUEHANNA.					
Sherman's Valley Light, Heat & Power Co., ...	Shermans Creek, ...	Loysville, ...	.....	30	7
Shippensburg Gas & Electric Co., ...	Conodoguinet Creek,..	Roxbury, ...	40	350	25
	Mill Spring Creek, ..	Near Shippensburg, ...	45	86	13
	Mill Spring Creek, ..	Near Shippensburg, ...	46	85	12
Big Springs Electric Co.,...	Conodoguinet Creek,..	Newville, ...	263	180	7
Carlisle Heat & Power Co.,	Conodoguinet Creek,..	Near Carlisle, ...	342	275	8
Mt. Holly Light, Heat & Power Co., ...	Mountain Creek, ...	Mt. Holly Springs,.....	47	150	14
J. C. Bucher, ...	Boiling Springs, ...	Boiling Springs, ...	.....	84	12
Kraybill Light, Heat & Power Co. (The M. E.), ..	Yellow Breeches Creek.	Leidigh Station, ...	163	200	7
Dillsburg Light, Heat & Power Co., ...	Yellow Breeches Creek.	Brandtsville, ...	170	90	8
S. R. Smith Co., ...	Yellow Breeches Creek.	Grantham, ...	184	96	5
Blue Mountain Electric Co.,	Slubert Run, ...	Bethel, ...	1	75	350
Hummelstown Cons. Water Co., ...	Swatara Creek, ...	Hummelstown, ...	512	200	9
York Haven Water & Power Co., ...	Susquehanna River,..	York Haven, ...	25,000	24,500	22
Wrightsville Light & Power Co., ...	Kreutz Creek, ...	Wrightsville, ...	35	120	17
Michael Nolt, ...	Conestoga Creek, ...	Near Terre Hill, ...	51	91	10
C. S. Wenger, ...	Conestoga Creek, ...	Brownstown, ...	120	50	8
Lancaster County Water & Power Co., ...	Conestoga Creek, ...	Wabank, ...	393	240	9
	Conestoga Creek, ...	Slackwater, ...	397	1,000	16
	Conestoga Creek, ...	Rock Hill	398	450	9

—*Continued*

Wheels.		Generators.				Auxiliary Plants.	
No.	Type.	No.	Capacity—kw.	AC or DC.	Make.	Capacity.	Number and Character of Units.
2	Doble Impulse,	2	240	AC	General Electric.	None.	Storage reservoir plant.
2	33-in. Victor, ..	1	125	AC	Stanley, ...	None.	
1	40-in. Smith, ...	1	30	AC	Westinghouse,	60 hp., ...	Slide valve engine.
2	33-in. Smith, ...	1	250	AC	Westinghouse,	.....	Steam plant of company.
2	33-in. Smith, ...	2	120	AC	.....	350 hp., ...	Steam engines.
4	39-in. double runner Smith.	4	500	AC	General Electric.	3500 kw., ...	Steam turbines.
2	42-in. double runner Leffel.	2	1,000	AC	Westinghouse.	500 kw., ...	Plant under construction.
1	36-in. double runner Leffel.	1	625	AC	Westinghouse,		
1	8-ft. Overshot,	1	60	AC	Warren, ...	35 hp., ...	Steam engine.
4	26-in. Sampson,	2	150	AC	Wood, ...	None, ...	Power sold as secondary.
1	.....	1	30				
1	35-in. Trump, ..	1	250	AC	Fort Wayne,	400 kw., ...	Steam plant of company at Shippensburg.
2	20-in. Trump, ..	1	75	AC	Fort Wayne,	.....	Steam plant of company at Shippensburg.
1	35-in. Leffel, ...	1	60	AC	.....	.....	Steam plant of company at Shippensburg.
3	45-in. Sampson,	1	75	AC	.....	75 hp., ...	Steam engine.
		1	100	DC			
5	53-in. Smith, ...	1	200	AC	Crocker-Wheeler.	1800 kw., ...	Steam station at Carlisle.
2	Smith, ...	2	50	DC	Triumph, ...	300 kw., ...	Steam turbine.
						200 kw., ...	Steam engine.
1	36-in. Burnham,	1	50	AC	Westinghouse,	None.	
2	33-in. Smith, ...	1	200	AC	.....	None, ...	Auxiliary contemplated.
1	48-in. Smith, ...	....	.....	.....			
1	56-in. Leffel, ...	1	75	AC	Wood, ...	125 hp., ...	Steam engine.
3	42-in. Smith, ...	1	100	AC	Wood, ...	None.	
		1	15	AC	Hawthorn.		
1	Pelton, ...	1	30	AC	Westinghouse,	40 hp., ...	Gas engine.
2	Trump & Smith.	1	100	AC	Allis - Chalmers.	500 hp., ...	Steam engine.
20	78.5-in. double runner Pocle.	20	750	AC	Stanley, ...	.....	Auxiliary power purchased.
2	30-in. Smith, ...	1	60	AC	Stanley.	250 hp., ...	Steam engine.
1	30-in. Leffel, ...	1	38	AC	Stanley, ...	50 hp., ...	Gas engine.
1	23-in. Leffel, ...	....	.....	.....			
1	36-in. Smith-McCormick	1	35	AC	Warren, ...	None.	
3	48-in. Smith-McCormick.	1	175	AC	Stanley	None, ...	Secondary power sold.
2	42-in. Smith, ...	1	750	AC	Allis - Chalmers.	None, ...	Secondary power sold.
2	42-in. Victor, ..	....	.....	.....			
2	72-in. Smith, ...	1	350	AC	Allis - Chalmers.	None, ...	Secondary power sold.

TABLE No. 5

Name of Owner.	Stream.	Location.	Drainage area—sq. mi.	Capacity—hp.	Head—feet.
Strasburg Electric Light, Heat & Power Co.,	Pequea Creek,	Wheatland Mills,	78	190	13
	Pequea Creek,	Edisonville,	80	90	8
Colemanville Water & Power Co.,	Pequea Creek,	Colemanville,	148	500	28
Pennsylvania Water & Power Co.,	Susquehanna River,..	Holtwood,	26,770	118,000	58
Delta Water Power Co.,	Muddy Creek,	Near Delta,	154	300	21
Delta Electric Power Co.,	Muddy Creek,	Near Delta,	140	500	42
Deer Creek Water & Water Power Co.,	E. Branch Deer Creek.	Stewartstown,	5	50	30
				147,982	
POTOMAC.					
Conococheague Electric Light, Heat & Power Co.,	W. Branch Conococheague Creek.	Mercersburg,	106	35	10
MIDDLE ALLEGHENY.					
Red Bank Electric Co.,	Red Bank Creek,	New Bethlehem,	500	260	8
LOWER ALLEGHENY.					
White Oak Light, Heat & Power Co. (The),	Stony Creek,	Hollsopple,	125	100	11
MONONGAHELA.					
Yough Hydro Electric Co.,	Youghiogheny River,	Ohio Pyle,	1,060	60	25
MAIN OHIO.					
Pennsylvania Power Co.,	Connoquenessing Creek	Ellwood City,	840	1,500	24
Beaver County Light Co.,	Beaver River,	Fallston,	3,010	400	9
				1,900	
		Grand total,		172,872	

—*Continued*

Wheels.		Generators.				Auxiliary Plants.	
No.	Type.	No.	Capacity—kw.	AC or DC.	Make.	Capacity.	Number and Character of Units.
2	30-in. Smith-McCormick.	1	160	AC	General Electric.	150 hp., ...	Power purchased to operate induction motor.
2	33-in. Smith-McCormick.	1	75	AC	Stanley, ...		
2	30-in. Leffel, ...	1	425	AC	Westinghouse,	600 hp., ...	Corliss engine.
5	105.5-in. double runner Morris.	2	10,000	AC	General Electric.	.....	Operated in connection with steam plants.
2	97.5-in. double runner Morris.	3	7,500	AC	General Electric.		
1	Single runner Morris.	3	12,000	AC	Westinghouse,		
1	24-in. double runner Smith.	1	100	AC	Westinghouse,	None.	
1	24-in. single runner Smith.	1	65	AC			
2	24-in. Smith, ...	1	350	AC	Stanley, ...	None.	
1	18-in. Smith, ...	1	30	AC	Westinghouse,	90 hp., ...	Gas engine.
2	21-in. McCormick	1	35	AC	Fort Wayne,	150 hp., ...	Steam engine.
2	33-in. Victor, ..	1	75	AC	Crocker-Wheeler.	300 hp., ...	Gas engine.
1	42-in. Victor, .	1	150	AC			
		1	250	AC	General Electric.		
1	30-in. Smith, ...	2	11	DC	.....	18 hp., ...	Gasoline engine.
1	24-in. Smith, ...	....	.....	.....	.....	115 hp., ...	Steam engine.
1	36-in., ...	1	45	AC	Westinghouse,	None.	
2	54-in. Smith, ...	2	625	AC	Westinghouse,	1000 kw., ...	Steam turbines.
2	.....	1	120	DC	Brush, ...	2500 kw., ...	Steam turbines.
		1	120	DC	Wood.		

USE OF STEAM POWER

Water power must be sold in actual or potential competition with steam-produced energy, and the feasibility of a development depends largely upon the relation of its cost of production to that of steam-made power. The market cost of the latter limits the selling price of water-generated energy, and, therefore, the amount which can be economically expended in hydroelectric development. The relation between the two methods of production is so intimate that it is advisable to examine some of the features of steam power generation.

The use of steam power is so extensive in Pennsylvania that it now dominates the central station and electric railway field. During the period of development of electrical transmission and of the use of central stations, the steam engine was generally the prime mover, and the extent to which it occupies the field is shown by the following figures from the United States Census of 1912:

Total capacity of central stations and electric railway stations in Pennsylvania, ...	908,879 hp.
Capacity of stations driven by steam engines and steam turbines, ...	753,468 hp.
Capacity of stations driven by water power,....	133,018 hp.
Capacity of stations driven by gas and oil engines,	22,393 hp.

If water power be developed in an amount only sufficient to care for new business, it must still meet steam competition and be delivered at or below the price that steam power can command. The hydraulic development which cannot do this will be unable to pay the investment charges and must reduce the operating costs, or reorganize with a reduction of capital; this fact is confirmed by the history of water power plants.

Moreover, free competition in the public service power business no longer exists. The principle upon which the control of corporations or companies serving the public is based, is that a regulated monopoly offers better service than competition, because the latter tends to combinations with unnecessary duplication of capital charges. This principle has been announced by the Public Service Commission of Pennsylvania in the "Ashland case." Water power companies must, therefore, secure control of existing distributing systems or wholesale their output to those supplying the public. Such combinations will not normally be effected unless economy of production is assured, except in the case of a water power development for partial or complete industrial utilization.

In studying the cost of steam power, recourse was had chiefly to published information; in addition, managers of steam-generating plants were interviewed and information obtained which verified the published data.

Introduction of the Steam Turbine:

A present tendency is toward the greater use of steam turbines as prime movers in central stations. A bulletin of the United States Census for 1912 shows this unmistakably, the summarized data being reproduced in Table No. 6.

TABLE No. 6. *Capacities of Steam Central Stations and Electric Railways in the United States*

Year.	Total steam in horse-power.	Steam engine in horse-power.	Per cent of total.	Steam turbine in horse-power.	Per cent of total.
1902,	2,702,602	2,702,602	100	*	.....
1907,	5,104,800	3,751,986	73	1,352,814	27
1912,	8,116,086	3,598,830	44	4,517,256	56

*Not reported.

These statistics show a revolutionary change; within 10 years after the introduction on a commercial basis, 56 per cent of the total installations in the United States employ steam turbines, while the capacity of reciprocating steam engines has actually diminished.

The advantages of the steam turbine over the reciprocating engine are:

1. A smaller outlay for the same capacity and efficiency.
2. Less floor space and consequent reduced expense for building.
3. A high rotative speed, giving lower cost for the electric generator.

The low cost of turbines has encouraged the use of improved auxiliary equipment, and steam turbine plants generally operate at higher efficiency than reciprocating units.

The best figures available show that there are installed in electrical central stations in Pennsylvania, steam engines and steam turbines, aggregating 58,000 hp. and not including stations supplying power solely to electric railways. Of this total, more than 60 per cent is produced by steam turbines.

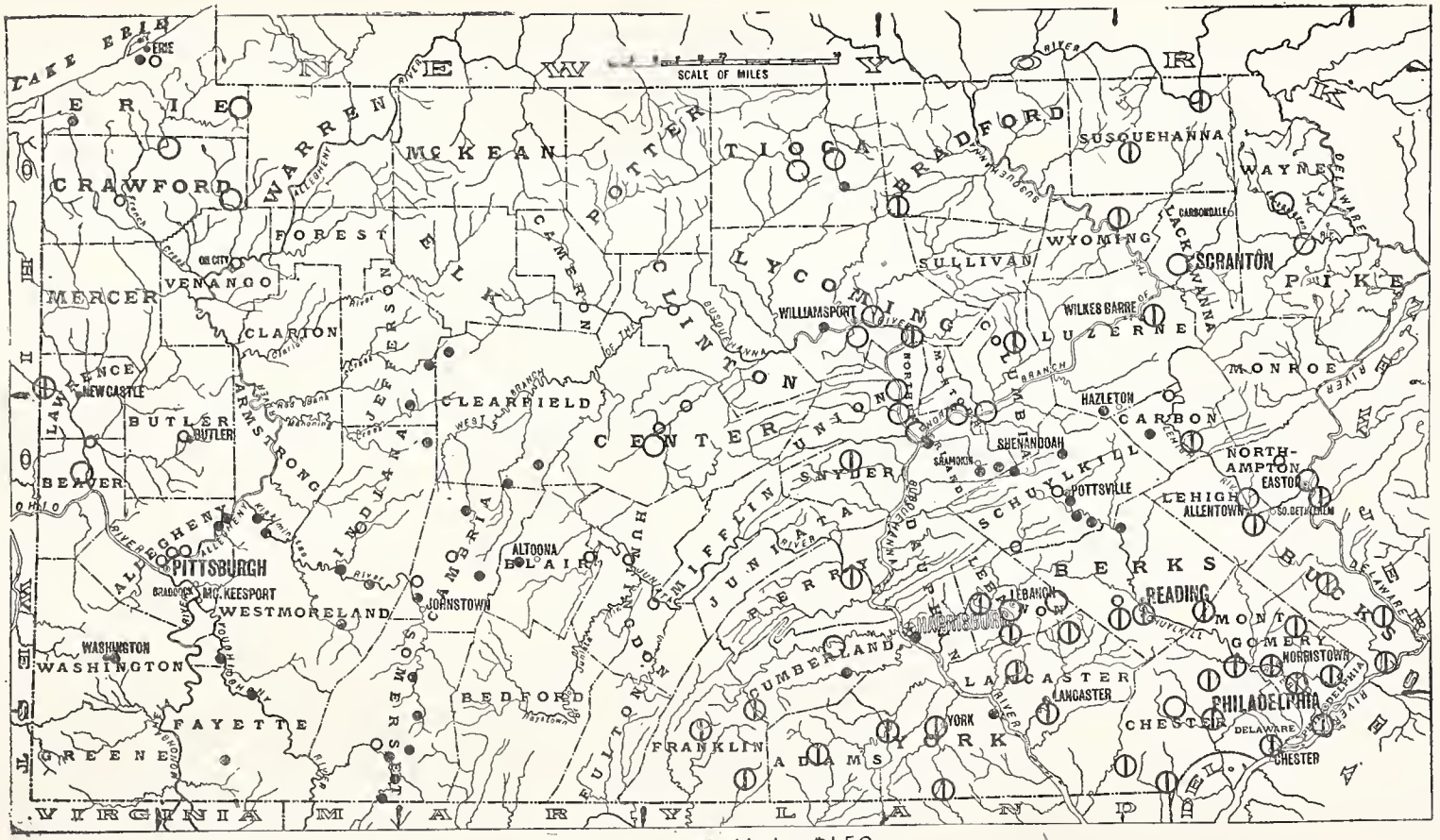
From these figures, Table No. 7 has been prepared, showing the steam stations of 2,000 hp. capacity or more. Of 40 stations, aggregating 476,000 hp., 33 operate in part by steam turbines, and 7 small plants depend entirely upon reciprocating engines.

TABLE No. 7. *List of Steam Central Stations Over 2,000 Horsepower*

City.	Company.	Capacity.
Allegheny,	Municipal,	2,900
Allegheny,	Pennsylvania Light and Power Co.,	6,500 T
Allentown,	Lehigh Valley Light and Power Co.,	10,400 T
Chester,	Beacon Light Co.,	3,900 T
Coatesville,	Chester Valley Electric Co.,	2,500 T
Connellsville,	West Penn Electric Co.,	17,200 T
Dalton,	Scranton and Binghamton Traction Co.,	2,200 T
Downingtown,	Chester Valley Electric Co.,	2,100 T
Easton,	Pennsylvania Utilities Co.,	12,800 T
Erie,	Erie County Electric Co.,	11,800 T
Erie,	Erie Lighting Co.,	6,000 T
Harrisburg,	Harrisburg Light and Power Co.,	8,700 T
Hauto,	Lehigh Navigation Electric Co.,	40,000 T
Hazleton,	Harwood Electric Co.,	20,100 T
Johnstown,	Citizens Light, Heat and Power Co. of Pennsylvania,	11,500 T
Lancaster,	Edison Electric Co.,	10,000 T
Lansford,	Lehigh Coal and Navigation Co.,	4,200
Lebanon,	Edison Electric Illuminating Co. of Lebanon,	2,100 T
Lemoyne,	United Electric Co.,	2,200
New Brighton,	Beaver County Light Co.,	2,300 T
New Castle,	New Castle Electric Co.,	2,760 T
New Kensington,	Allegheny Valley Street Railway Co.,	2,700
Norristown,	Counties Gas and Electric Co.,	3,100 T
Oil City,	Citizens Light and Power Co.,	4,000 T
Petersburg,	Penn Central Light and Power Co.,	3,400 T
Philadelphia,	Philadelphia Electric Co.,	171,700 T
Phoenixville,	Philadelphia Suburban Gas and Electric Co.,	2,000
Pittsburgh,	Duquesne Light Co.,	25,000 T
Plymouth,	Luzerne County Gas and Electric Co.,	5,500 T
Pottsville,	Eastern Pennsylvania Light, Heat and Power Co.,	6,800 T
Reading,	Metropolitan Electric Co.,	18,100 T
Scranton,	Scranton Electric Co.,	22,800 T
Shamokin,	Pennsylvania Lighting Co.,	3,500 T
Sunbury,	Northumberland County Gas and Electric Co.,	2,700 T
Washington,	Washington Electric Light and Power Co.,	2,000
Wayne,	Counties Gas and Electric Co.,	2,200
Wilkes-Barre,	The Wilkes-Barre Co.,	6,400 T
Williamsport,	Citizens Electric Co.,	2,000 T
Williamsport,	Lycoming Edison Co.,	5,100 T
York,	Edison Light and Power Co.,	4,700 T

"T" indicates that a portion or all of the equipment consists of steam turbines.

While during recent years water wheel efficiencies have been increased and the construction of hydroelectric plants has been improved, the cost of steam power has also materially diminished. The best steam practice secures at the electrical generator less than 20 per cent of the energy stored in the coal, and, under normal operating conditions, few plants obtain an efficiency of 15 per cent. At present there is little indication of further improvement, yet there is a wide opportunity for the invention of improved devices to secure the highest economic utilization of the fuel employed. The efficiency of water wheels has been increased until now it frequently exceeds 90 per cent at maximum, and little further improvement may be expected.



PRICES

- ● Under $1.50
- ○ $1.50-$2.00
- ◯ $2.00-$2.50
- ⦶ Over $2.50

Fig. 6. Map showing price of coal at steam stations

Price of Coal:

The "McGraw Electrical Directory" reports for a number of stations the prices of coal used, which are assumed to be f. o. b. cars at or near the plant. No indication is given, as a rule, as to the grade of fuel. The map, Fig. 6, has been prepared from these data, and shows how the price of coal varies throughout the State. It indicates the number of steam plants in operation and exhibits certain zones of concentration. Examination of Fig. 6, in connection with Fig. 4, page 20, shows that in the region of the cheapest coal in southwestern Pennsylvania there are practically no hydroelectric plants. In the Upper Allegheny and the Upper West Branch Susquehanna drainage basins there are few power stations of any kind, while the majority of hydroelectric plants are in the Lower Susquehanna Valley and the southeast corner of the State, where the price of coal is much higher.

Cost of Production:

Available records show extreme variation in the cost of generating steam power at existing plants, the switchboard cost of producing electric energy being reported as low as one-half cent per kw.-hr. in efficient stations with high load factor, while at plants with low load factor, it is as high as 5 or 6 cents. The present consideration is the cost of securing steam power under conditions of competition with water power. If competition by water power be threatened, the tendency will be to increase the efficiency of the steam-driven plant, and this will be facilitated by the low installation cost of the steam turbine.

Determining the cost of power production includes: First, the investment charges, which cover interest, amortization, depreciation, taxes, insurance and any other expenses which are fixed charges upon the capital invested, independent of the load and character of service; second, the operating expenses, such as fuel, station wages, supplies, renewals and repairs; third, the administrative and superintendence charges of conducting the business of power *generation*. The principal expenses of most electric light and power companies are incurred in the *distribution* of the power, and are not a proper charge against the generating station.

As illustrative of the low cost of steam power produced on a large scale, certain figures are submitted, quoted from Mr. H. M. Hobart, in "Proceedings of the American Institute of Electrical Engineers, March, 1914." Mr. Hobart discussed a plant with five units of 20,000 kw. capacity each. He assumed a peak load of 80,000 kw., which allows one spare unit, and stated that such a plant can be

installed complete, including land, buildings and auxiliary equipment for the most economical production, for $35.00 per kw. (not, however, in large cities). Mr. Hobart discussed various load factors, but taking only that of 50 per cent, gives an annual production at the switchboard of 350,000,000 kw.-hrs. Assuming coal containing 12,000 B. t. u. per lb., costing $2.00 per ton, and an overall efficiency of 13 per cent (or 2.2 lbs. of coal per kw.-hr.), Mr. Hobart computed the total cost of power at switchboard as 5.75 mills per kw.-hr.

The price of $2.00 per ton for coal is about the average for Pennsylvania, and is readily obtained in the great industrial centers of the western part of the State. To illustrate the influence of the price of coal, other things being equal, Fig. 7, taken from Mr. Hobart's paper is presented. (These data omit any discussion of the effect of power factor so as to avoid complications).

Some station operators of western Pennsylvania, who obtain coal at between $1.00 and $1.50 per ton, state that they have actually reached a cost of production, upon the basis outlined above, of 5 mills per kw.-hr. at the switchboard. A fuel consumption of 3 lbs. of coal per kw.-hr. has been claimed in plants not remarkably efficient, and published data indicate that 2.5 lbs. and even less has been reached in well designed and well managed plants, but in these the load factor has exceeded 50 per cent.

Such figures, however, do not fairly represent average practice, and Prof. Daniel W. Mead states that a fair estimate of the average amount of coal used in the generation of power is about 3 lbs. per hp.-hr. (or 4 lbs. per kw.-hr.). The curve of Fig. 8 is compiled from reports of the New York Public Service Commission (Second District) for 1912, and shows the coal consumed in steam stations of Class A Electric Corporations. This curve is practically horizontal at 4 lbs. per kw.-hr. for the greater part of its length, and the rate of consumption increases when the daily output becomes small. This represents a fuel cost, at $2.00 per ton, of 4 mills per kw.-hr. Where the points fall below the curve the load factor of the plant is high, approaching 70 per cent.

With the cheapest coal and a load factor of not less than 50 per cent, the switchboard cost of production may be brought to 5 mills per kw.-hr. in large plants. As the price of coal increases and the size of plant diminishes, a good load factor still being assumed, the cost of power will advance considerably, but with coal not over $3.50 per ton, as it is in most centers of Pennsylvania, any new steam station of 5,000 kw. or more, should generate electricity at about one cent per kw.-hr., or even less.

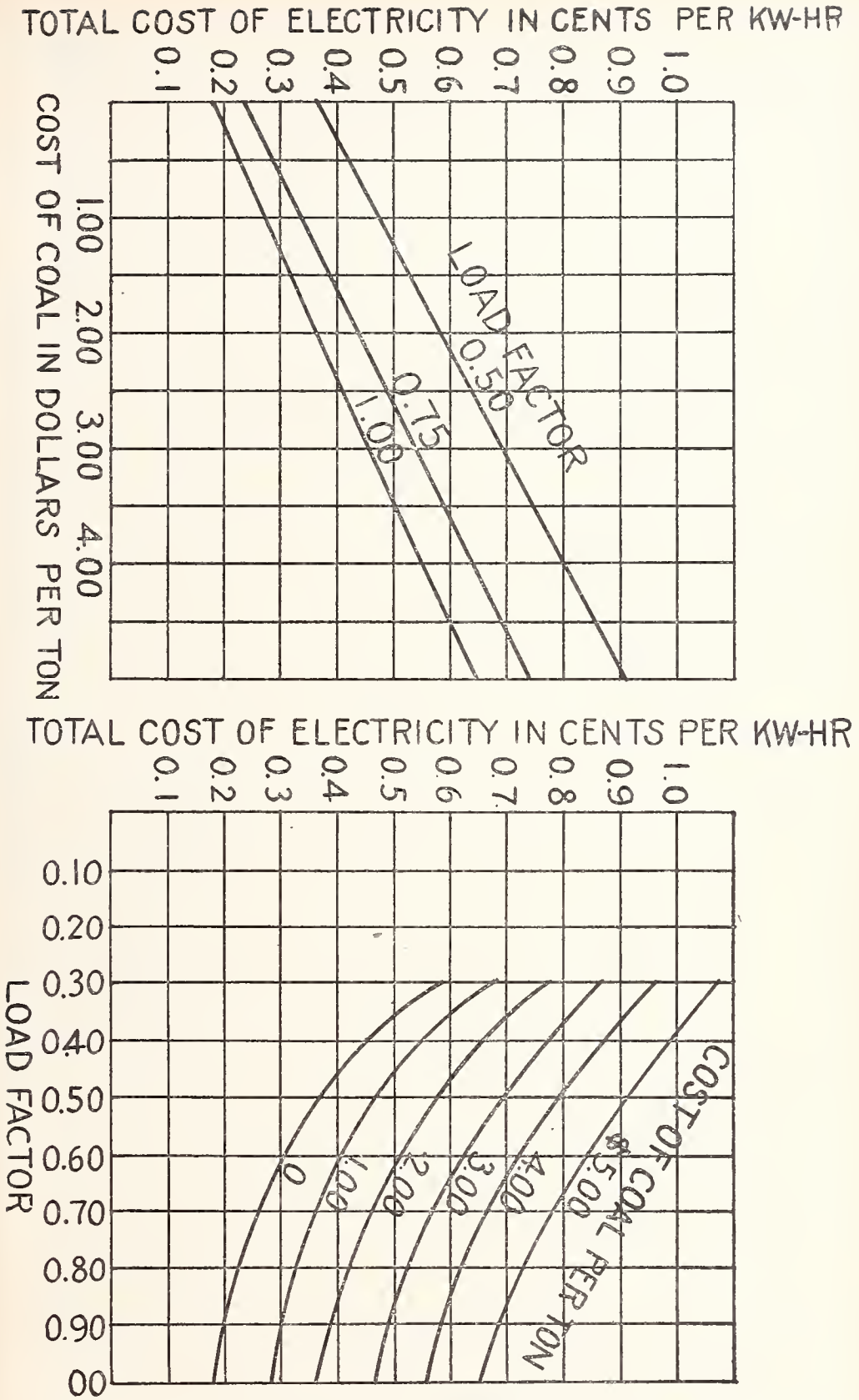


Fig. 7. Curves showing attainable cost of production of electricity in large steam stations

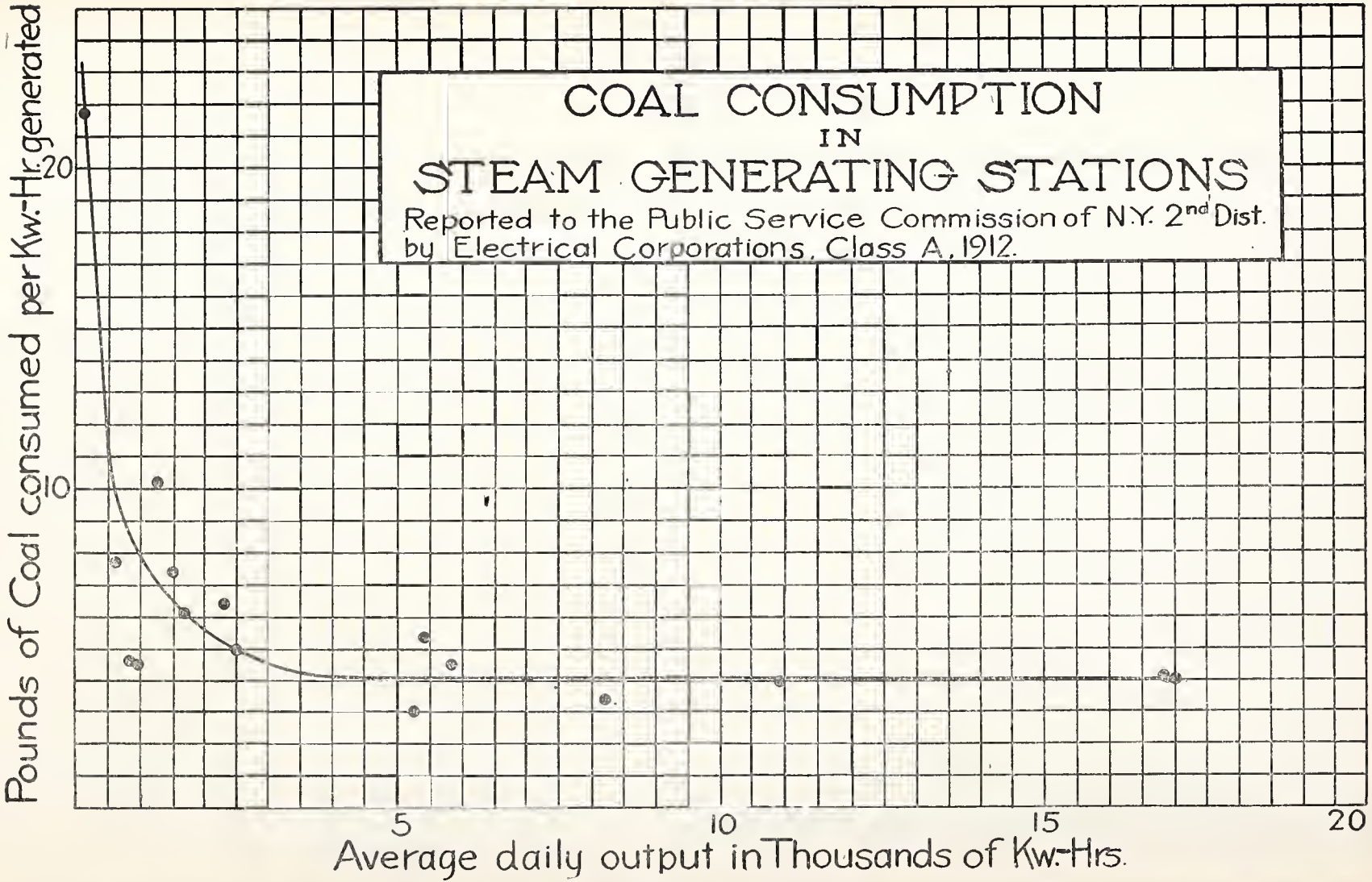

COAL CONSUMPTION
IN
STEAM GENERATING STATIONS
Reported to the Public Service Commission of N.Y. 2nd Dist.
by Electrical Corporations, Class A, 1912.
Pounds of Coal consumed per Kw.-Hr. generated
20
10
5
10
15
20
Average daily output in Thousands of Kw.-Hrs.

Fig. 8.

Water Power Limitations:

Hydroelectric energy must be sold at points of consumption or distribution at rates equal to or lower rates than those commanded by steam power. As hydroelectric stations are generally distant from markets, transmission lines are necessary, and the interest and maintenance charges on these become additional elements of cost.

If continuity of hydroelectric energy cannot be guaranteed, that is if it must be sold as secondary power, the price must approximate the cost of producing supplementary power by steam. This is due to the necessity of maintaining the steam station and its operating force to secure continuity of service.

The parallel operation of steam stations and hydroelectric plants offers many advantages because the load of central stations varies widely throughout the day. When water is plentiful, the hydraulic station carries a load up to its capacity, the steam plant operating only when the demand exceeds this load. When the water supply is low this process is reversed, the hydraulic station storing water during most of the day. Such operation is most effective under common ownership or control of water and steam plants, and provides, where there are no large storage reservoirs, the most efficient use of the combined sources of energy.

Parallel operation offers superior economy in another manner. On streams in Pennsylvania, it is feasible to carry the major portion of the load during most of the year on the hydraulic station. With such operation only a small proportion of the total energy is produced by steam, and the fuel item is small. This is well demonstrated in the systems examined.

The profitable production of hydroelectric energy is thus largely dependent upon the conditions of steam power production in the market, and the price varies with many factors, prominent among which are the price of coal, the efficiency of steam equipment, both present and anticipated, and the character of load.

It is difficult to make close comparisons between the cost of steam power and hydraulic power; but consideration of the data herein discussed and of the curves of Fig. 5, page 26, shows that in large plants there is not a wide difference. Small steam plants are characterized generally by low load factors and high fuel consumption, operating expenses forming a large portion of the total high production cost. Such cases offer to the water plant an opportunity which has been grasped by many successful companies. These plants, however, have small capacity, even in the aggregate, and are of minor public interest. The larger installations promise greater benefits to the public in regulating streams and conserving

the coal supply, but are apparently more sensitive to competitive limitations. Under present conditions, the development of water power will be limited unless the cost of construction is reduced, or revenues are increased by realizing upon the indirect benefits which would arise from stream regulation.

UNDEVELOPED WATER POWER

Detailed descriptions of the undeveloped water power resources have not been included because sufficient funds were not available for a proper study of the same. Few sites offer opportunity for cheap development, and heavy investments are necessary for construction on a large scale. Many apparently promising sites cannot be profitably developed under the adverse conditions heretofore described. To determine the availability of our power sites for successful utilization requires careful study and examination and includes detailed inspection of many streams. Such examinations should be supplemented by surveys at critical points, by geological examination, possibly even by borings, the reliability of such information being proportionate to the thoroughness of investigation. Much of the work must necessarily show negative results; that is, close examination will prove certain sites are not economically available.

Pending applications for incorporation of water power companies have been examined in connection with the Inventory study, but such investigations by no means covered the total undeveloped power of the State. The examinations have been sufficiently thorough to determine the feasibility of the proposed developments and whether such developments would be in harmony with the best utilization of the water resources affected. They have also indicated the probable lines of future development and the strong tendency toward the use of storage reservoirs.

Some examinations have also been made of reports on file with the Commission, which show the characteristics of the undeveloped projects to which charters have been granted since 1905. The tendencies of these can be observed from the following discussion of the various schemes upon which the Commission has acted favorably.

On page 19, a statement is given of the number of companies incorporated since the establishment of the Water Supply Commission

and also the number of such plants constructed and in operation. In Table No. 8, is a list of projects incorporated but not built. All of these propose to use water power for generating electric current, and the total estimated capacity is 336,260 hp., or about twice that of plants now operating.

TABLE No. 8. *Incorporated Water Power Projects Not Built*

Company.	Date Incorporated.	Estimated Capacity in hp.
Mahantongo Water Power Co.,	Sept. 13, 1905,..	2,500
Nanticoke Power Co.,	Nov. 29, 1905,..	1,500
The Penn Water Power Co.,	July 12, 1906,..	.....
Iroquois Water & Power Co., and Watts Power & Water Co.,	Oct. 30, 1907,..	7,000
Union County Power Co.,	Nov. 7, 1903,..	925
Union Water Power Co.,	Dec. 31, 1908,..	575
Pittsburgh Hydro Electric Co.,	Aug. 5, 1909,..	25,000
Ohio Pyle Falls Development Co.,	Feb. 1, 1911,..	9,600
The Citizens Water Power Co.,	July 6, 1911,..	2,100
The Shohola Falls Hydro Electric Co.,	Jan. 12, 1912,..	15,000
Kittanning Water Power Co.,	May 10, 1912,..	28,000
Clarion River Power Co.,	June 7, 1912,..	224,000
Riceville Power Co.,	June 28, 1912,..	60
Pennsylvania, New York & New Jersey Power Co.,	Jan. 27, 1913,..	15,000
Bradford Power Co.,	Oct. 10, 1913,..	5,000
Total,	.....	336,260

The principal features of various projects incorporated are discussed below.

Mahantongo Water Power Co.:

This development was to be on the east bank of the Susquehanna River, about two miles north of Millersburg, Dauphin County. The plans covered a concrete dam extending over about one-half of the river to divert water by a forebay along the shore to a long power house with an ultimate capacity of 2,500 hp., developed by twenty 68-in. turbines under 8 ft. head to produce alternating current probably for the Harrisburg market. This company acquired control of some of the necessary property, but its works have never been built.

Nanticoke Power Co.:

This company proposed a dam about one mile below Nanticoke on the North Branch of the Susquehanna River, employing the site of an old canal dam. An installation of from 1,000 to 2,000 hp. was probably intended, and some repair work on the old dam is said to have been done. It was reported in 1908 that financial conditions had delayed work, and nothing tangible has been done since.

Penn Water Power Co.:

This company was incorporated July 12, 1906, by the incorporators of the Raystown Water Power Co., for the purpose of, "The supply, storage and transportation of water and water power for commercial and manufacturing purposes, in the Township of Penn, County of Huntingdon, State of Pennsylvania," and was intended to be used in connection with the development of the Raystown Water Power Co., then under construction on the Raystown Branch of the Juniata River. The Penn Water Power Co. charter was approved by the Commission upon condition that work be commenced within one year from the date of incorporation and completed within 5 years thereafter. This condition was not complied with and the charter reverted to the Commonwealth because of non-user.

An application for a new charter covering the same territory as that contained in the charter of the Penn Water Power Co., under the name of the Allegrippus Water Power Co., is now pending before the Water Supply Commission.

Iroquois Water & Power Co. and Watts Power & Water Co.:

These two companies were formed under a common ownership to cover a single development on the Juniata River, about 5 miles above its mouth, the charters applying to townships on opposite sides of the river. The drainage area of the river above the site is about 3,500 square miles. It was proposed to build a concrete dam about 500 ft. long and 18 ft. high, and install 7,000 hp. of water wheels, with an auxiliary steam plant of about 2,000 hp., transmitting alternating current at 33,000 volts to Harrisburg and neighboring towns.

Union County Power Co.:

This company was organized to develop Rapid Run, a tributary of Buffalo Creek, in Union County, with a drainage area of 25 square miles. The development was to include a small diversion dam and a 40-in. conduit, 4 miles long, to obtain 410 ft. head, to operate three Pelton wheels aggregating 925 hp. and a steam auxiliary of 700 hp. The dam would be sufficiently large to secure pondage, but not seasonal storage. The proposed market included Mifflinburg, Lewisburg, Sunbury, etc., but the district has since been partly supplied with current by other water power companies.

Union Water Power Co.:

This company proposed a small plant on Chillisquaque Creek, in Northumberland County, just above the mouth of the stream where the drainage area is 109 square miles, by using the site of

an existing mill and rebuilding the old dam to obtain 12 ft. more head. A 6-ft. conduit, 2,400 ft. long, would give 27 ft. gross head, and the contemplated installation was three turbines, aggregating 575 hp. and steam auxiliary of 460 hp. capacity.

Pittsburgh Hydro Electric Co.:

A charter was obtained to cover a portion of a large development in northern West Virginia, whose storage reservoir extended into Wharton Township, Fayette County, Pa., and contemplated the complete utilization of Big Sandy Creek, a tributary of the Cheat River, draining about 200 square miles. The storage reservoir, containing 2,300,000,000 cubic feet, was planned to control 92 square miles of watershed and would lie on both sides of the Pennsylvania-West Virginia Line. Water from the lower portion of the stream was to be diverted through a canal about 4.5 miles long, developing 525 ft. net head, to operate machinery of 25,000 hp.

This scheme is important as being the first large scale, high head and storage development chartered in Pennsylvania. It is understood that the nature of the development in West Virginia has been somewhat modified to increase the capacity and output. The project reached the construction stage, but the company being a subsidiary of the American Water Works & Guarantee Co., which failed in July, 1913, the work has been suspended.

Ohio Pyle Falls Development Co.:

This company proposed to develop the Youghiogheny River at Ohio Pyle, Fayette County, where the stream has a drainage area of about 1,000 square miles. The river forms a large horseshoe at this site and the scheme involved a canal across the neck about 1,200 ft. long. By a diversion dam and the cut-off, it was expected to develop 85 ft. head and to secure sufficient water to operate wheels of 9,600 hp. This was regarded as secondary power and was to be sold in conjunction with the output of a large steam plant.

Citizens Water Power Co.:

This company proposed to develop power at Williamsport on the West Branch of the Susquehanna River, at a site above the existing dam at that city. The plans covered a concrete dam about 12 ft. high with 2 ft. of flashboards in addition, 14 water wheels, aggregating 2,100 hp., and 3 generators of 1,400 kw. total capacity; the plant to operate in connection with a steam station. A peculiar property situation has been largely responsible for failure to build.

Shohola Falls Hydro Electric Co.:

This corporation was formed for a water power on Shohola Creek, in Pike County, a tributary of the Upper Delaware. It is a high head and storage development on a stream with a total drainage area of 84 square miles, of which 60 would contribute to the project. The dam, 60 ft. in height, would cause the submergence of 2,000 acres and secure 3,500,000,000 cubic feet of storage, by which the company expected to obtain a regulated discharge of 120 second-feet. With a 78-in. wood stave pipe line, 4 miles long, including 4,000 ft. of tunnel, 550 ft. net head would be obtained to operate a water wheel capacity of 15,000 hp.

Kittanning Water Power Co.:

This corporation was formed to develop Crooked and Cowanshannock creeks, both entering the Allegheny River near Kittanning. The Crooked Creek development proposed a dam about 170 ft. high, with a tributary drainage area of 275 square miles. By utilizing the upper 50 ft. of the reservoir, a storage of about 14,000,000,000 cubic feet was expected, with a mean regulated flow of 550 second-feet. The power house, a mile below, was to be connected with the dam by a steel penstock, securing about 200 ft. average net head to operate water wheels of 20,000 hp. capacity.

A development of similar nature proposed for Cowanshannock Creek included a 200-ft. dam about one mile above the mouth, where the drainage area is 62 square miles, and 4,000 ft. of penstock to the power house, with a water wheel capacity of 8,000 hp. By using the upper 40 ft. of the reservoir 5,000,000,000 cubic feet of storage and 286 ft. average net head were claimed as obtainable. This reservoir was expected to submerge 3,900 acres, and give a mean regulated flow of 124 second-feet.

It is understood that these plans have been altered, but that the magnitude and general characteristics of the system are substantially as stated.

Clarion River Power Co.:

This company was formed for the complete development of the Clarion River, a tributary of the Upper Allegheny River, which, flowing through comparatively thinly settled country from its headwaters in McKean and Elk counties, has a total drainage area of 1,232 square miles. At the time of application for charter it was proposed to build two dams, one near the mouth about 200 ft. high, and the other near the town of Clarion about 300 ft. high. These developments proposed to use the upper 40 to 50 ft. of the reservoirs

for storing approximately 19,000,000,000 cubic feet and would have together an average head of 460 ft. It is understood that some modifications in the plans have been made, as a result of which, slightly greater capacity is to be secured, although the character of the development will be essentially the same. About 224,000 hp. of water wheel capacity was contemplated.

Riceville Power Co.:

This charter covers a small proposed development on the West Branch of Oil Creek, at Riceville, Crawford County, where the drainage area is 19 square miles. It was proposed to use an old mill site and to build a dam 14 ft. high and 160 ft. long. Three water wheels would develop a total of 60 hp.

Pennsylvania, New York & New Jersey Power Co.:

This company proposed a full development of Wallenpaupack Creek, a tributary of the Lackawaxen River, forming the boundary between Wayne and Pike counties. The stream drains 240 square miles, nearly all tributary to the proposed storage reservoir. A dam, 45 ft. in height, will submerge 5,700 acres and secure 5,500,000,000 cubic feet of storage. A conduit from the reservoir to the mouth of the stream about a mile below, will give an average head of 300 ft. on water wheels of 15,000 hp. capacity.

Bradford Power Co.:

This project was proposed on the North Branch of the Susquehanna River, about 2 miles below the Borough of Towanda. An Ambursen reinforced concrete dam, about 23 ft. high and 2,200 ft. long, was proposed, the power house to have a capacity of about 5,000 hp. This development would be dependent on an existing steam station for auxiliary service in the low water season.

The above descriptions show that five of the projects, covering 307,000 hp., are characterized by storage regulation and high head. Seven, aggregating 28,275 hp., involve the use of low or moderate heads on streams of large drainage area and heavy although fluctuating discharge, and also rely on auxiliary steam plants for the maintenance of service. One project is to develop high head without storage and use a steam auxiliary. It is noteworthy that storage reservoirs are proposed only at high head plants while auxiliary service is depended on to maintain service at all others. While detailed estimates of cost are not available, the aggregate expenditure necessary for these projects is approximated at $50,000,000.

These projects, prior to their approval, were examined by engineers of the Commission and while their studies were only preliminary, they have shown that the schemes were practicable, and were considered to have a reasonable chance of success. While a scarcity of investment capital at this time strongly retards development, it cannot well be maintained that this condition has prevailed uniformly since 1905, when the first of these projects was chartered. It has been previously shown that seven existing plants aggregating 149,800 hp. were incorporated previous to the organization of this Commission in 1905, and that only four plants of 5,825 total hp. have been incorporated and built since that time.

That these plants have not yet been constructed is significant. A frequent reason is that preliminary engineering studies were not sufficiently thorough to accurately determine the cost and output. In some cases, further investigation has shown less water available than had been counted upon, or has demonstrated a cost so much above that originally calculated as to prevent the proposition from becoming a paying venture. Sometimes investigation showed that the market for power would not meet expectations as to quantity or price. A fundamental reason assigned for the failure to construct works chartered is the uncertainty concerning legislation and the legal rights possessed by the companies. All these difficulties and the unfortunate financial experience of some who have constructed works have contributed to prevent capital from investing in these projects.

Pending Applications:

A number of applications for incorporation are now before the Commission, involving aggregate capacities far in excess of those hitherto discussed. These comprise chiefly projects on the Delaware River and the tributaries of the Allegheny, and also some miscellaneous schemes.

The Upper Delaware River is proposed to be utilized by a series of low head developments in conjunction with storage reservoirs in New York and Pennsylvania. Because of the interstate character of the stream, Federal legislation must probably be secured and any permit must also be subject to the agreement of 1783 between New Jersey and Pennsylvania, providing for concurrent jurisdiction over this river.

A series of developments are contemplated on the Tionesta, Redbank and Mahoning creeks and Kiskiminitas River and their tributaries. The incorporators propose storage reservoirs on the upper waters, with plants at the reservoirs, and also farther down the

streams wherever suitable sites and the absence of railroads permit profitable development. These projects would aid in regulating the flow of the Allegheny River. Similar projects are proposed on Connoquenessing and Slippery Rock creeks in Mercer, Lawrence and Butler counties, one of whose effects would be a material increase in the summer flow of the Beaver and the Ohio rivers.

Smaller developments without storage are proposed on Bushkill Creek, in Monroe County; Redbank Creek, in Clarion County, and on Iser's Run, in Somerset County, but are without significance so far as stream regulation is concerned.

Efforts are also being made to develop the Susquehanna River below Holtwood, utilizing the head of about 110 ft. between that point and Chesapeake Bay. This involves the construction of dams and power houses in Maryland. The backwater effect in Pennsylvania, with possible markets in this State, are the phases with which we are chiefly concerned.

As these schemes have not yet reached the stage of incorporation, their details are not properly open to comment.

Conclusions:

Water power occupies a position of basic importance in any water conservation policy, and its development should be encouraged by legislative enactment along proper lines and under proper control. In Parts VI and VIII of the Water Resources Inventory Report, are discussed the bearing which water power development has on water supply and flood control problems. The investigation so far conducted has shown that the conditions adversely affecting water power development are of sufficient moment to justify the State in determining the feasible projects and facilitating their development. Every large development effected is of public value, if properly operated and controlled, and is worthy of support.

A complete investigation to be effective requires examination of a large number of unmapped streams, inspection of a few of the mapped ones; and surveys and geological and hydrographic studies at important points. Liberal expenditures are necessary and reimbursement to the State of expenses incurred in the study of any project might well be made a prerequisite of incorporation. This work could be carried on to advantage during the next two years and would be of great value in enabling the Commission to formulate the future policy of the State.

METHODS OF IMPROVEMENT

Value of Regulation:

Previous discussion has shown the desirability of water power utilization, its tendency to affect stream regulation, and the principal obstacles to its development, viz: variation in stream flow, competition with cheap steam-made power, and high costs of land and construction. Below are considered methods of encouraging development, both for the conservation of energy and for the indirect benefits to be derived from regulated stream flow.

Reforestation is claimed to increase the ground storage of water and give a slower rate of run-off, thus reducing flood discharges and erosion, and maintaining a more uniform supply throughout the year. Others hold that reforestation would diminish the dry weather flow, for although there is less evaporation of rainfall, the transpiration by growing trees is considerable. Such conclusions are mainly applicable to newly planted forests and to the period which includes their growing season. Credit must be given to a humus floor for its greater catchment factor and slower run-off because of its porosity. Shallow freezing, and the uneven surface of and the obstructions on the forest floor retard the run-off, and consequently steady both the surface and sub-soil drainage. Quantitive data are meager, and so many factors, especially meteorological and geological ones, enter into investigations, that determination of the increase of flow to be expected has not yet been satisfactorily made. Reforestation, with the preservation and proper management of existing forests, is, however, so obviously desirable for timber conservation that it is worthy of strong support regardless of the extent to which it benefits the streams of the Commonwealth.

Storage Reservoirs afford the most reliable method of securing adequate water in the dry season, by retaining the heavy run-off of the wet months to be released as needed. These assure to the public an increased low water flow for sanitation and navigation, for industrial purposes, and furnish a measure of protection from flood damage. These advantages obtain, to a certain degree, even in a reservoir operated purely for a private water power. The variation in load on the water power plant may produce diurnal irregularity in the flow below; but generally, the low water discharge is increased by such manipulation. The Water Supply Com-

mission, in granting charters recently to corporations proposing to use storage reservoirs, stipulated that the dry weather flow existing previous to construction must be maintained for the benefit of riparian owners downstream. That such dry weather flow is small compared with the quantity to be regularly used is indicated by the fact that this condition has been agreed to without protest.

Continuity of power operation requires in general that the reservoir be kept as full as possible, to hold an adequate supply of water for a long continued drought. This is somewhat inconsistent with the use of the same reservoir for flood protection, which use, when exclusive, requires that the reservoir be kept as empty as possible so that it may have its maximum capacity available for flood discharge. However, in both cases, the object is to retain the heavy flow, and storage reservoir operation on a large scale for power purposes only will absorb considerable of the flood flow. In general, the larger the reservoir, relative to the drainage area of the stream, the greater the proportion of flood flow that it will absorb.

There is small probability that the maximum flood will occur when the reservoir is full. While floods regularly occur in the spring and are relied upon for storage, on most Pennsylvania streams the maximum known flood has occurred in the summer or fall, (See Part VIII of the Water Resources Inventory Report) when the water in reservoirs is likely to be at a low level. Moreover, a large reservoir, even when full, will mitigate floods; for in raising the water level, the flow is retarded and the intensity of the flood at points below is diminished.

The possibilities of the storage reservoir as protection against flood damage are so great that co-operation of the public authorities with power companies would be in many cases expedient. Where flood storage can be secured by raising a dam, it is fair that the communities benefited should bear at least a portion of the expense.

Public Ownership:

Methods of securing water power improvements will vary accordingly as they are to be employed under public or corporate ownership. In the former case the State may build reservoirs and operate power plants connected therewith, although power houses or their sites may be leased to other parties under guarantees as to rates of flow in the streams. In many cases, stream regulation for navigation or flood amelioration may permit power development which should pay a portion of the cost of the regulating works. An interesting improvement has been advocated for one of the streams of the State, which borders a city of some size. Reservoirs are to hold back flood water, which when released will increase low

water flow and render possible the navigation of the river below the city, as well as the development of power for lighting the municipality. Although not designed primarily to produce water power, the Pymatuning Reservoir, the construction of which is under contemplation by the State, is a striking example of the possibility of stream regulation under public authority.

Corporate Ownership:

While water power projects have hitherto been owned by private corporations, the tendency of late has been to modify existing laws, chiefly to prevent permanent private control.

Recent legislation of the Federal Government and of a number of the States, while granting water rights on the public lands to approved corporations, has imposed certain restrictions. The term of franchises has been limited, with an option of purchase on its expiration by the State or Federal Government. As a rule, charges have been imposed for the rights granted in the form of rentals based either on the horsepower developed or on the gross earnings. On navigable rivers, the Federal Government has required some water power grantees to construct locks and other works for the benefit of navigation. It is believed reasonable in Pennsylvania, to limit the term of charters to fifty years, the State to have an option to purchase upon a predetermined basis at the end of such period, and in case of failure to exercise such option, the franchise to continue for another fixed period under such restrictions as may be in force at the time of expiration. A period of less than fifty years is insufficient to attract capital. Special taxation or rentals should not be imposed upon these corporations if such additional burdens will hinder desired developments. The approval of plans by the Water Supply Commission should be required before construction, and the right to acquire property should not become effective until after such approval and until the need therefor and the financial ability of the corporation has been certified by the Public Service Commission.

Modification of Forestry Laws:

Projects for developing power have been prevented because a portion of the necessary lands lay within the State Forest Reserves and the Forestry Department has been without authority to lease or grant the required lands. While there may be objections to the passage of title of State lands, there should be no opposition to the leasing of lands required by an approved water power company, provided the Public Service Commission certify to the need of such lands.

Revenue from Indirect Benefits:

Reference has been made to the benefits accruing to communities below a water power storage because of the regulation of flow provided, and it is equitable that compensation for these benefits should be paid the company conferring them. At this time no method exists for assessing and collecting such benefits, but the formulation of methods for distributing the costs of river improvement in proportion to the benefits received is worthy of thorough investigation and careful thought.

Scope of Investigations:

Every stream presents local conditions which will determine the most advantageous type of development; hence, no general plan can be wisely advocated until much further detailed study has been made. For instance, on many streams there is no opportunity for the construction of storage reservoirs at any reasonable cost, and on such streams little can be effected in the way of power development except at certain exceptional sites. Others are capable of regulation, by reservoirs, to a high degree of uniformity of flow, with consequent multiplication of their uses.

Several of the most important power streams in the State are of an interstate character. The Delaware River is a boundary stream with some power sites occurring within the combined jurisdiction of New York, New Jersey and Pennsylvania. There are also storage possibilities in New York and Pennsylvania; in this State, charters have been granted to power companies proposing to construct two of these, although the sites of the largest reservoirs are in New York. The Susquehanna River also offers possibilities between the Maryland line and its mouth, but any regulation of the river as a unit must be chiefly in Pennsylvania, which embraces most of the drainage area. The Monongahela River may possibly be regulated by reservoirs in West Virginia and Maryland. All these rivers require joint State action for their best utilization, and comprehensive plans must be evolved under joint jurisdiction of the several States affected. An earnest effort should be made to agree with the authorities in adjoining States on the adoption of a harmonious policy.

While the importance of a regulated flow has been previously dwelt upon, the regulation effected by power development need not be complete. It is necessary to pass varying quantities of water through the wheels to meet the demands of the load and considerable daily fluctuations in flow may occur below any plant. A storage reservoir if sufficiently large equalizes the annual flow and renders

water available in times of drought. Daily variations in flow may be largely equalized if a series of plants are operated in combination. The primary function of streams is to afford water for domestic supplies; their use for power involves no consumption of water, and, insofar as regulation is effected, increases the quantities available for the higher uses. The development of water power, therefore, is in harmony with the conservation of natural resources, and should be encouraged wherever possible. With this thought in view, in order to afford the fullest possible information to those interested, the inventory of water powers should be completed.

Discharge Data:

The Water Supply Commission, under authority granted it by the General Assembly, has pursued a comprehensive program of stream measurements to determine their discharges. The earlier water power developments undoubtedly suffered from a lack of definite knowledge of this kind, and intelligent planning of future developments requires such data as a basis. These cannot be too complete, and in connection with the studies recommended in the section on Undeveloped Water Power will be of tremendous value in aiding future development.

Conclusions:

The Commission does not recommend a definite water power policy at this time, because of the lack of information concerning the extent and value of the undeveloped powers. In order to reach a conclusion the following subjects among others should be covered:

1. Examinations, surveys and geological studies of all important streams to determine the feasible water power of the State with approximate cost of development.
2. Revenue which may be expected in direct returns from the sale of power if developments are made by the State, and the indirect returns from prevention of floods and droughts, aid to navigation and industry and improvement of sanitary conditions.
3. Consideration of water supply needs and how best they may be met through power development; also of geographical divisions in connection with distributing systems for electric power and for water supply.
4. Complete review of the laws relating to water power development, of this State, and of others whose legislation reveals the present tendencies. The existing laws of neighboring States should be studied to determine their effect upon the development of streams within this State.

APPENDIX A

TABLES OF WATER POWER CORPORATIONS

TABLE No. 9. *Water Power Companies Incorporated Previous to Organization of Water Supply Commission, May 4, 1905*

Company.	County.	Town, Borough or Township.	Date Incorporated.
New Brighton Water Co.,	Beaver,		April 16, 1838.
Fallston Water Co.,	Beaver,		April 8, 1848.
Towanda Water Co.,	Bradford,	Towanda,	Mar. 31, 1851.
Beaver Falls Water Power Co.,	Beaver,	Beaver Falls,	April 10, 1867.
Western Water Power Co.,			April 9, 1870.
The Schuylkill Valley Water Storage, Water Power and Transportation Co.	Philadelphia,		Feb. 13, 1885.
Beaver Water Power Co.,	Beaver,	Beaver Falls,	June 21, 1889.
The Conewago Water and Power Co.,	Lancaster,	Columbia,	Nov. 15, 1894.
York Haven Water and Power Co.,	York,	York Haven,	Jan. 16, 1895.
Lower Chanceford Water and Power Co.	York,	Lower Chanceford,	Mar. 14, 1895.
Martic Water and Power Co.,	Lancaster,	Martic,	Mar. 14, 1895.
Sowego Water and Power Co.,	Lancaster,	Fulton,	Mar. 14, 1895.
Delaware River Power Co.,	Bucks,	Morrisville,	June 25, 1896.
The Conoy Water and Water Power Co.	Lancaster,	Conoy,	July 17, 1896.
Beaver River Power Co.,	Beaver,		Aug. 13, 1897.
The Eastern Water Power Co.,	Philadelphia,		Jan. 11, 1899.
The Bucks County Water and Water Power Co.	Bucks,	Solesbury,	Mar. 27, 1899.
The Bath Water and Power Co.,	Northampton,	Bath,	April 11, 1899.
French Creek Water Power Co.,	Chester,		July 11, 1899.
Peoples Water and Power Co. of Red Lion.	York,	Red Lion,	Feb. 6, 1900.
Slatington Power Co.,	Lehigh,	Slatington,	Mar. 5, 1900.
Windber Water and Power Co.,	Somerset,	Paint and Shade,	April 26, 1900.
The Rutherglen Water and Power Co.	Clearfield,	Chest,	May 10, 1900.
Peoples Power and Water Co.,	York,	Fairview,	June 6, 1900.
The Yellow Creek Water Power Co.,	Bedford,		July 20, 1900.
Ellwood Power Co. (1),	Lawrence,	Ellwood City,	Oct. 19, 1900.
Yardley Water and Power Co.,	Bucks,	Yardley,	Dec. 19, 1900.
Core Creek Water Power Co.,	Bucks,	Yardley,	Jan. 28, 1901.
Pike Water Power Co.,	Wayne,	Hawley,	April 1, 1901.
Mauch Chunk Water Power Co.,	Carbon,	Lehigh,	April 22, 1901.
West Susquehanna Water Power Co.,	Clearfield,		April 29, 1901.
South Penn Water and Electric Power Co.	Bedford,	Hopewell,	May 10, 1901.
Lackawaxen Water Power Co.,	Pike,	Lackawaxen,	May 21, 1901.
Armagh Water Power Co.,	Mifflin,	Armagh,	Aug. 26, 1901.
Swiftwater Water and Power Co.,	Monroe,	Swiftwater,	April 14, 1902.
Beaver Valley Water Power Co.,	Beaver,	Beaver Falls,	April 30, 1902.
Chanceford Water and Power Co.,	York,	Chanceford,	May 23, 1902.
Conestoga Water and Power Co.,	Lancaster,	Conestoga,	May 23, 1902.
Drumore Water and Power Co.,	Lancaster,	Drumore,	May 23, 1902.
Fulton Water and Power Co.,	Lancaster,	Fulton,	May 23, 1902.
Lower Windsor Water and Power Co.	York,	Lower Windsor,	May 23, 1902.
Manor Water and Power Co.,	Lancaster,	Manor,	May 23, 1902.
Muddy Creek Water and Power Co.,	York,	Lower Chanceford,	May 23, 1902.
Peach Bottom Water and Power Co.,	York,	Peach Bottom,	May 23, 1902.
Pequea Water and Power Co.,	Lancaster,	Martic,	May 23, 1902.
Alexandria Water and Water Power Co.	Huntingdon,	Porter,	June 30, 1902.
Susquehanna Storage, Lake and Power Co.	York and Lancaster,		Aug. 14, 1902.
Susquehanna Falls Power Co.,	York and Lancaster,		Aug. 14, 1902.
Susquehanna River Power Co.,	York and Lancaster,		Aug. 14, 1902.
Delaware Water Gap Water Power Co.	Monroe,	Smithfield,	Aug. 26, 1902.
Hillside Water and Power Co.,	York,	Lower Chanceford,	Sept. 2, 1902.
Susquehanna Water and Power Co.,	Lancaster,	Martic,	Sept. 2, 1902.
Long Level Water and Power Co.,	York,	Lower Windsor,	Nov. 13, 1902.
Pennsylvania-Susquehanna Power Co.,	Lancaster,	Manor,	Nov. 13, 1902.
Shenks Ferry Water and Power Co.,	York,	Chanceford,	Nov. 13, 1902.
Little Juniata Water and Power Co.,	Huntingdon,	Logan,	Feb. 11, 1903.

TABLE No. 9—*Continued*

Company.	County.	Town, Borough or Township.	Date Incorporated.
The Monroe County Water Power and Supply Co. (2).	Monroe, ...	Stroudsburg, ...	Feb. 11, 1903.
Monroe Water and Power Co., ...	Monroe, ...	.....	May 5, 1903.
Deer Creek Water and Water Power Co.	York, ...	Stewartstown, ...	Dec. 17, 1903.
Portland Water and Power Co., ...	Northampton, ...	.....	Feb. 9, 1904.
Bushkill Power Co., ...	Monroe, ...	Middle Smithfield, ..	Feb. 26, 1904.
Northwestern Water Power Co., ...	Allegheny, ...	.....	Mar. 31, 1904.
Juniata Water and Water Power Co. (3).	Huntingdon, ...	Smithfield, ...	June 15, 1904.
Providence Hydro Electric Co., ...	Bedford, ...	.....	June 16, 1904.
Millstone Water and Power Co., ...	Lancaster, ...	Conestoga, ...	July 14, 1904.
Rural Water and Power Co.,.....	Lancaster, ...	Manor, ...	July 14, 1904.
Wayne Storage Water Power Co.,....	Wayne, ...	.....	Aug. 16, 1904.
Colemanville Water and Power Co.,	Lancaster, ...	Conestoga, ...	Sept. 9, 1904.
The Safe Harbor Water and Power Co.	Lancaster, ...	.....	Oct. 6, 1904.
Pennsylvania Power Co. (1), ...	Lawrence, ...	Ellwood City, ...	Dec. 7, 1904.
Valley Water Storage Co., ...	Cambria, ...	Dean, ...	Jan. 5, 1905.
Blair Water Power Co., ...	Blair, ...	Snyder, ...	Mar. 11, 1905.
McCall Ferry Power Co. (4), ...	Lancaster and York.	.....	April 14, 1905.

Active companies are indicated by heavy faced type.
(1) Plant now owned by the Pennsylvania Power Co.
(2) Plant now owned by the Central Broadheads Power Co.
(3) Company reorganized as Pennsylvania Hydro Electric Co.
(4) Company reorganized as Pennsylvania Water and Power Co.

TABLE No. 10. *Water Power Companies Incorporated Since the Organization of the Water Supply Commission, May 4, 1905*

Company.	County.	Town or Township.	Stream.	Date Incorporated.
Mahantongo Water Power Co.,	Dauphin & Perry,		Susquehanna River,	Sept. 13, 1905.
Nanticoke Power Co.,	Luzerne,	Nanticoke,	North Branch Susquehanna River,	Nov. 29, 1905.
The Raystown Water Power Co.,	Huntingdon,	Juniata,	Raystown Branch Juniata River,	Mar. 30, 1906.
The Penn Water Power Co.,	Huntingdon,	Penn,	Raystown Branch Juniata River,	July 12, 1906.
Delta Water Power Co.,	York,	Lower Chanceford,	Muddy Creek,	Oct. 29, 1906.
Iroquois Water & Power Co.,	Perry,	Miller,	Juniata River,	Oct. 30, 1907.
Watts Power & Water Co.,	Perry,	Watts,	Juniata River,	Oct. 30, 1907.
Yeagertown Water Power Co.,	Mifflin,	Derry,	Kishacoquillas Creek,	Sept. 5, 1908.
Union County Power Co.,	Union,		Rapid Run,	Nov. 7, 1908.
Union Water Power Co.,	Northumberland,	West Chillisquaque,	Chillisquaque Creek,	Dec. 1, 1908.
Pittsburgh Hydro Electric Co.,	Fayette,	Wharton,	Big Sandy Creek,	Aug. 5, 1909.
Asylum Water Power Co.,	Bradford,	Asylum,	Susquehanna River,	Sept. 17, 1909.
Borough Water Power Co.,	Bradford,	Towanda,	Susquehanna River,	Sept. 17, 1909.
North Towanda Water Power Co.,	Bradford,	N. Towanda,	Susquehanna River,	Sept. 17, 1909.
Sheshequin Water Power Co.,	Bradford,	Sheshequin,	Susquehanna River,	Sept. 17, 1909.
Towanda Water Power Co.,	Bradford,	Towanda,	Susquehanna River,	Sept. 17, 1909.
Ulster Water Power Co.,	Bradford,	Ulster,	Susquehanna River,	Sept. 17, 1909.
Wysox Water Power Co.,	Bradford,	Wysox,	Susquehanna River,	Sept. 17, 1909.
The Paupack Power Co.,	Pike,		Wallenpaupack Creek,	Oct. 4, 1910.
Ohio Pyle Falls Development Co.,	Fayette,		Youghiogheny River,	Feb. 1, 1911.
Wallenpaupack Power Co.,	Pike,	Palmyra,	Wallenpaupack Creek,	June 27, 1911.
The Citizens Water Power Co.,	Lycoming,	Williamsport,	West Branch Susquehanna River,	July 6, 1911.
The Shohola Falls Hydro Electric Co.,	Pike,	Shohola,	Shohola Creek and trib.,	Jan. 12, 1912.
Central Broadheads Power Co.,	Monroe,	Stroud,	Brodheads Creek,	Apr. 29, 1912.
Lower Broadheads Power Co.,	Monroe,	Smithfield,	Brodheads Creek,	Apr. 29, 1912.
Middle Brodheads Power Co.,	Monroe,	Stroudsburg,	Brodheads Creek,	Apr. 29, 1912.
Upper Broadheads Power Co.,	Monroe,	East Stroudsburg,	Brodheads Creek,	Apr. 29, 1912.
Barnett Water Power Co.,	Jefferson,	Barnett,	Clarion River,	May 1, 1912.
Clarion River Power Co.,	Clarion,	Clarion,	Clarion River,	May 1, 1912.
Farmington Water Power Co.,	Clarion,	Farmington,	Clarion River,	May 1, 1912.
Forrest Water Power Co.,	Forest,	Barnett,	Clarion River,	May 1, 1912.
Heath Water Power Co.,	Jefferson,	Heath,	Clarion River,	May 1, 1912.
Highland Water Power Co.,	Clarion,	Highland,	Clarion River,	May 1, 1912.
Licking Water Power Co.,	Clarion,	Licking,	Clarion River,	May 1, 1912.
Mill Creek Water Power Co.,	Clarion,	Mill Creek,	Clarion River,	May 1, 1912.
Millstone Water Power Co.,	Elk,	Millstone,	Clarion River,	May 1, 1912.
Monroe Water Power Co.,	Clarion,	Monroe,	Clarion River,	May 1, 1912.
Paint Twp. Water Power Co.,	Clarion,	Paint,	Clarion River,	May 1, 1912.
Perry Water Power Co.,	Clarion,	Perry,	Clarion River,	May 1, 1912.

TABLE No. 10—*Continued*

Company.	County.	Town or Township.	Stream.	Date Incorporated.
Richland Water Power Co.,	Clarion,	Richland,	Clarion River,	May 1, 1912.
Kittanning Water Power Co.,	Armstrong & Indiana,		Crooked & Cowanshannock,	May 10, 1912.
Clarion River Power Co. (Merger),	Clarion, Elk, Jefferson & Forest.		Clarion River,	June 7, 1912.
Rieeville Power Co.,	Crawford,	Riceville,	Oil Creek, West Branch,	June 28, 1912.
Central Broadheads Power Co. (Merger),	Monroe,		Brodheads Creek,	Jan. 20, 1913.
Pennsylvania, New York & New Jersey Power Co. (Merger),	Pike & Wayne,		Wallenpaupaek Creek,	Jan. 27, 1913.
Phoenix Water Power Co.,	Montgomery,	Upper Providence,	Schuylkill River,	Apr. 25, 1913.
Buchanan Water & Power Co.,	Lancaster,	Lancaster,	Conestoga Creek,	May 13, 1913.
Hamilton Water & Power Co.,	Lancaster,	Manor,	Conestoga Creek,	May 13, 1913.
Lafayette Water & Power Co.,	Lancaster,	Pequea,	Conestoga Creek,	May 13, 1913.
Stevens Water & Power Co.,	Lancaster,	Conestoga,	Conestoga Creek,	May 13, 1913.
Lancaster County Water & Power Co.,	Lancaster,		Conestoga Creek,	June 9, 1913.
Bradford Power Co. (Merger),	Bradford,		Susquehanna River,	Oct. 10, 1913.

TABLE No. 11. *Water Power Companies Operating Hydroelectric Plants*

Company.	Hydraulic capacity in hp.
Central Broadheads Power Co. (Plant built by Monroe County Water Power & Supply Co.),	1,250
Colemanville Water & Power Co.,	500
Deer Creek Water & Water Power Co.,	50
Delta Water Power Co.,	200
Lancaster County Water & Power Co. (3 plants),	1,690
Pennsylvania Water & Power Co. (Formerly McCall Ferry Power Co.),	118,000
Pennsylvania Power Co.,	1,500
Pennsylvania Hydro Electric Co. (Formerly Juniata Water & Water Power Co.),	4,000
Phoenix Water Power Co.,	1,125
Raystown Water Power Co., (The),	3,900
Yeagertown Water Power Co.,	500
York Haven Water & Power Co.,	24,500
Total number of companies—12. Total capacity,	157,315

TABLE No. 12. *Consolidations and Mergers of Water Power Companies*

Constituent Companies.	Merged or Consolidated Company.	Date of Merger.
Chanceford Water & Power Co.,	Susquehanna Storage, Lake & Power Co. (Controlled by Pennsylvania Water & Power Co.)	Aug. 14, 1902.
Conestoga Water & Power Co.,		
Lower Windsor Water & Power Co.,		
Manor Water & Power Co.,		
Drumore Water & Power Co.,	Susquehanna River Power Co. (Controlled by Pennsylvania Water & Power Co.)	Aug. 14, 1902.
Fulton Water & Power Co.,		
Peach Bottom Water & Power Co.,		
Muddy Creek Water & Power Co.,	Susquehanna Falls Power Co. (Controlled by Pennsylvania Water & Power Co.)	Aug. 14, 1902.
Pequea Water & Power Co.,		
Hillside Water & Power Co.,	McCall Ferry Power Co. (Became Pennsylvania Water & Power Co. Jan. 14, 1910).	April 14, 1905.
Susquehanna Water & Power Co.,		
Barnett Water Power Co.,	Clarion River Power Co.,	June 7, 1912.
Clarion River Water Power Co.,		
Farmington Water Power Co.,		
Forrest Water Power Co.,		
Heath Water Power Co.,		
Highland Water Power Co.,		
Licking Water Power Co.,		
Mill Creek Water Power Co.,		
Millstone Water Power Co.,		
Monroe Water Power Co.,		
Paint Township Water Power Co.,		
Perry Water Power Co.,		
Richland Water Power Co.,		
Central Broadheads Power Co.,	Central Broadheads Power Co.,	Jan. 20, 1913.
Lower Broadheads Power Co.,		
Middle Broadheads Power Co.,		
Upper Broadheads Power Co.,		
Paupack Power Co. (The),	Pennsylvania, New York & New Jersey Power Co.	Jan. 27, 1913.
Wallenpaupack Power Co.,		
Asylum Water Power Co.,	Bradford Power Co.,	Oct. 10, 1913.
Borough Water Power Co.,		
North Towanda Water Power Co.,		
Shesheguin Water Power Co.,		
Ulster Water Power Co.,		
Wysox Water Power Co.,		
Towanda Water Power Co.,		

TABLE No. 13. *Light, Heat and Power Companies Operating Water Power Plants*

Name.	Office.	Date of incorporation or mergers.	Hydraulic capacity in hp.
Beaver County Light Co.,	Beaver,	March 29, 1910	400
The Belleville Electric Co.,	Belleville,	Dec. 16, 1908	36
Benton Electric Co.,	Benton,	April 14, 1913	87
Big Springs Electric Co.,	Newville,	April 29, 1908	180
Birdsboro Electric Co.,	Birdsboro,	Feb. 24, 1897	100
Blue Mountain Electric Co.,	Bethel,	Nov. 16, 1906	75
Boalsburg Electric Co.,	Boalsburg,	Aug. 27, 1913	34
Carlisle Light, Heat & Power Co.,	Carlisle,	Oct. 2, 1911	275
Center Electric Co.,	Howard,	Feb. 18, 1913	100
Columbia & Montour Electric Co.,	Bloomsburg,	Nov. 7, 1912	710
Conococheague Electric Light, Heat & Power Co.	Markes,	Aug. 28, 1907	35
Delta Electric Power Co.,	Delta,	July 27, 1896	500
Dillsburg Light, Heat & Power Co.,	Dillsburg,	Oct. 13, 1910	90
Eaglesmere Light Co.,	Eaglesmere,	Sept. 14, 1900	924
Easton Gas Works (a),	Easton,	Jan. 22, 1912	1,400
Hummelstown Cons. Water Co. (b),	Harrisburg,	April 9, 1906	200
M. E. Kraybill Light, Heat & Power Co. (The).	Dillsburg,	Sept. 28, 1909	200
Middleburg Light, Heat & Power Co.,	Middleburg,	June 11, 1909	60
The Millersburg Electric Light, Heat & Power Co.	Millersburg,	March 24, 1891	160
Mt. Holly Light, Heat & Power Co. (c),	Mt. Holly Springs,	May 18, 1903	150
Northumberland County Gas & Electric Co.	Sunbury,	Sept. 20, 1911	400
Paupack Electric Co.,	Hawley,	March 20, 1906	400
Philadelphia Hydro Electric Co.,	Philadelphia,	Jan. 10, 1907	2,800
Philadelphia Suburban Gas & Electric Co. (c).	Philadelphia,	Dec. 15, 1913	500
Red Bank Electric Co.,	New Bethlehem,	July 26, 1910	260
Sherman's Valley Light, Heat & Power Co.	Loysville,	Feb. 23, 1910	30
Shippensburg Gas & Electric Co. (c),	Shippensburg,	Feb. 29, 1904	350 86 85
State Centre Electric Co. (c),	Bellefonte,	Nov. 24, 1913	200
Strasburg Electric Light, Heat & Power Co. (c).	Strasburg,	May 24, 1913	190 90
Susquehanna County Light & Power Co.	Scranton,	Dec. 8, 1913	300 800
Tunkhannock Electric Co.,	Tunkhannock,	Aug. 1, 1899	200
The White Oak Light, Heat & Power Co.,	Benson,	Dec. 7, 1909	100
Wrightsville Light & Power Co.,	Wrightsville,	Jan. 15, 1902	120
Yough Hydro Electric Co.,	Pittsburgh,	Dec. 9, 1912	60
Total number of companies—34.	Total capacity,		12,087

(a) Originally Easton Gas & Electric Co., incorporated June 24, 1910.
(b) Originally Hummelstown Water Co., incorporated June 20, 1887.
(c) Formed by Mergers of Consolidations.

APPENDIX B

DESCRIPTIONS OF HYDROELECTRIC PLANTS

These descriptions, presented as a supplement to the principal text on water power, are classified by sub-basins and illustrated by photographs, to show typical developments of the State. These plants are all utilized in the production of electric current for sale to the public, and the descriptions include the more important plants. Details of the small hydroelectric plants listed in Table No. 5, page 28, without features of special interest, have been omitted. These data are, however, on file with this Commission and may be obtained upon application.

UPPER DELAWARE SUB-BASIN

This sub-basin comprises the portion of the State which drains into the Delaware River above the mouth of the Lehigh River, and embraces all of Pike and portions of Wayne, Monroe, Northampton and Lackawanna counties. The region consists mostly of a moderately high plateau with some pronounced ridges, extending generally from southwest to northeast, and deeply cut by stream valleys. Practically the whole basin was covered with ice in the glacial period and the topography presents some of the features peculiar to such conditions. Many of the streams are characterized by steep slopes with lakes and swamps above, and in connection with low land values afford excellent opportunities for power development. Some of the best sites in the State are in this basin and several promising projects are being promoted. At present only three plants, of 1,685 aggregate horsepower, supply power to the public, although there are several small plants supplying lighting current only.

PAUPACK ELECTRIC CO.—WALLENPAUPACK CREEK

The plant is about one-half mile above the mouth of Wallenpaupack Creek, just above a silk mill operated by water power and owned by the Dexter-Lambert Co. About March 1, 1906, the Pau-

pack Electric Co. succeeded the Hawley Electric Light, Heat & Power Co., which had previously operated a water power plant at Hawley. The plant, constructed in 1897, was rebuilt in 1905, when a steam equipment was installed. The hydraulic capacity has since been increased by raising the dam and installing additional machinery.

The drainage area of the creek is about 230 square miles, mostly forest covered, and the fall is about 300 ft. in the mile immediately above its mouth. Above that the fall is slight for about 15 miles, and exceptional opportunity for storage is offered.

The existing plant is situated about the middle of the 300 ft. fall, of which only 90 ft. are now utilized. A concrete dam, 76 ft. long, built in 1913, to replace an old, arched timber dam, diverts water to a head race about 12 ft. square formed by a heavy concrete wall parallel to the side of the gorge. The wheels are mounted in a steel penstock, 7 ft. in diameter, and steel draft tubes discharge in a waste channel below.

The equipment includes two 23-in. turbines on a common horizontal shaft, developing together 400 hp. under 32 ft. head and 300 r. p. m., with a direct connected 175-kw. generator, producing alternating current. The plant is housed in a small concrete building on the side of the gorge and rests upon a masonry substructure founded on rock. A separate steam plant at the top of the gorge provides ample auxiliary power.

The company supplies the Borough of Hawley with light and also retails power and light, its motor load being about 250 hp. The plant is constructed in an exceptionally favorable location at low cost and gives satisfactory results, but will be replaced by the proposed full development of the 300 ft. head by the Pennsylvania, New York and New Jersey Power Co.

CENTRAL BROADHEADS POWER CO.—BRODHEADS CREEK

This plant, along the main line of the D. L. & W. R. R., is on Brodheads Creek, in Smithfield Township, Monroe County, about one mile above its mouth and one mile below the city of Stroudsburg. The plant was built between 1904 and 1907 by The Monroe County Water Power & Supply Co., and by Sheriff's sale on December 15, 1911, passed into the control of the interest owning the Pennsylvania Utilities Co. of Easton, in connection with whose steam plant it is now operated. In 1912 and 1913 water power charters were taken out by these interests for various townships in Monroe County and a merger effected by which the property is now in the control of the Central Broadheads Power Co.

Fig. 9. Station of the Central Broadheads Power Co., Brodheads Creek near Stroudsburg

Fig. 10. Station of the Clymer Power Co., Delaware Canal near Raubsville

Brodheads Creek, in the vicinity of the plant, has a rapid rate of fall, averaging from 40 to 50 ft. per mile. The stream has a drainage area of about 400 square miles, approximately 50 per cent forest covered. The watershed is mountainous and lies chiefly on the southeastern slope of the Pocono Mountains.

The development is direct, effected by a concrete dam with timber apron and having a crest elevation of 322 ft. above sea level; the head and pondage are increased by the use of 32-in. flash-boards. The dam is about 30 ft. high, 125 ft. long over the spillway, and founded upon gravel. Backwater extends for about one-half mile, but the steep slope and the narrow valley limit the pondage.

Two steel penstocks, 9 ft. in diameter and 50 ft. long are provided with gates and racks, while a floating timber boom deflects ice and trash from their entrances. The power plant is in a wooden building on concrete foundations and a maximum head of about 26 ft. is obtained, the average being about 23 ft. Two units of the horizontal shaft type have belt-driven generators. One unit has a single runner 42-in. wheel, rated at 500 hp. under 28 ft. head and connected to a 200-kw. generator. The other unit has two similar runners, together rated at 750 hp. under 20 ft. head, driving a 450-kw. generator. This double unit installed 3 years ago replaced a similar single unit.

The current is carried over a double circuit at 33,000 volts to the general transmission system of the Pennsylvania Utilities Co., centering at Easton. This power is distinctly auxiliary, reliance for steady service being placed upon a large steam plant at Easton.

MIDDLE DELAWARE SUB-BASIN

This sub-basin comprises chiefly the watershed of the Lehigh River, with some smaller streams tributary to the Delaware River. The Lehigh rises in the southern end of Wayne County among the mountain ridges which traverse this portion of the State and flows southerly and southeasterly to the Delaware at Easton. There are a number of water power developments along the river, practically all utilizing power developed by the dams and canals of the Lehigh Coal & Navigation Co., which are discussed in Appendix C, page 95. Four hydroelectric plants of 2,970 hp. aggregate capacity,

are now operating in connection with the canal under leases from the Navigation Company. One of these is on the Delaware at Raubsville, but it obtains its water from the canal by means of the dam across the Lehigh at Easton. In addition, several small plants are reported on Bear, Tobyhanna and Upper Tunkhannock creeks.

EASTON GAS CO.—LEHIGH RIVER

The Pennsylvania Utilities Co. operates a large power system centering at Easton, Pa., including the hydroelectric plant of the Easton Gas Co. at South Easton. The principal station of this system is the Dock Street Station at Easton, with a capacity of 20,000 hp. in steam power. The company also operates a 650-kw. electric plant at Stroudsburg under the name of the Central Broadheads Power Co., a steam station at Bangor, Northampton County, and also purchases some power from the Clymer Power Co., at Raubsville, Pa. The total capacity of its generating stations is about 30,000 hp., of which the one here described, the South Side Station, has a hydraulic capacity of 1,400 hp.

The plant is on the Lehigh Navigation Co's. canal on the south bank of the Lehigh River about one mile above the railroad station at Easton. It has been lately reconstructed, and contains, in addition to the hydroelectric plant, a reserve steam capacity of 2,500 hp.

The drainage area of the Lehigh River at this point is about 1,300 square miles and comprises chiefly mountainous and hilly country, largely in the anthracite regions. Diversion from the canal at the level of the Glendon Dam into the pool formed by the Easton Dam below gives a head of about 18 ft. Water passes through a concrete forebay, protected by racks, then through steel penstocks 10 ft. diameter and about 150 ft. long, to four turbines mounted in pairs with cylindrical gates in steel drums. The wheels are 60 in. in diameter, rated at 350 hp. per runner, direct connected to a 500-kw. AC generator, operating at 150 r. p. m. Excitation is provided by means of two 50-kw. exciters, installed above the wheel cases.

Power is delivered at 6,600 volts to the Dock Street Station, for distribution and further transformation, the current being largely secondary power in the general system. The steam reserve station in an adjoining building has fires banked for emergency service.

CLYMER POWER CO.—DELAWARE RIVER

The plant is on the Delaware Division of the Lehigh Canal, one-half mile below the village of Raubsville, Northampton County, and 2 miles above Reigelsville, Pa. It was built in 1907, replacing an

older plant constructed in 1903. The drainage area is 1,370 square miles, and the run-off from this entire area is always available for navigation and power purposes. The canal extends 5 miles without locks from the Easton Dam to the lock at Raubsville, where a fall of 32 ft. exists between the canal and the river. A portion of the water used must, however, be returned to the next level of the canal, and in the use of this water only 16 ft. head is available.

Water is drawn from the canal through an open concrete-lined channel, about 200 ft. long and 40 ft. wide, with a maximum depth of 13 ft. The power house is on the river bank and the discharge into the river requires no long tailrace, but that into the canal passes through another concrete-lined channel, about 150 ft. long, 30 ft. wide and 6 ft. deep.

The building is of brick on concrete foundations, and the wheels are on horizontal shafts in large concrete flumes with steel draft tubes. One unit comprises two turbines, operating under 32 ft. head and rated at 810 hp., and a 500-kw. alternating current generator. The other unit, under 16 ft. head, is of similar wheels, rated at 290 hp. and has a 250-kw. generator. All wheels are controlled by cylinder gates operated by governors, and two exciters at 20 kw. capacity deliver direct current. Ice protection is by a boom at the headrace and adequate lightning protection is provided.

The company supplies current principally to the Philadelphia and Easton Transit Co. which operates the interurban line connecting Doylestown with Easton. A rotary converter at the plant supplies the section nearest Easton, while other converters are in a sub-station at Plumsteadville, about 16 miles south. This sub-station is connected with the power plant by a 15,000 volt transmission line. Another similar line extends north to the Ferry Street sub-station of the Pennsylvania Utilities Co. at Easton, which company purchases surplus power from the Clymer Co.

It is stated that sufficient power is available to operate this plant throughout the year so far as the principal load is concerned. The Transit Company, however, has a reserve steam station at Raubsville which has been used in occasional emergencies.

LOWER DELAWARE SUB-BASIN

The Lower Delaware Sub-basin is almost synonymous with the Schuylkill Basin, for few streams drain directly into the Delaware. Nine hydroelectric plants, aggregating 5,030 hp. are on the Schuylkill or its tributaries of which five are constructed adjacent to the

canal of the Schuylkill Navigation Co. between Reading and the mouth of the river. There are also private plants, of which that of the French Creek Granite Co. at St. Peter's, Chester County, is most noteworthy.

The Lower Delaware Sub-basin lies mostly in the foothills of the Blue Ridge. The topography of the basin is uneven, but most of the drainage area is highly cultivated and thickly populated. The streams are generally of moderate slope and their flow is fairly regular as compared with those of the State in general.

The system of dams and canals of the Schuylkill Navigation Co. extends from Philadelphia to Port Clinton (90 miles), although no water power is developed above Reading. Details of this system, so far as the mechanical uses of water are concerned, are discussed in Appendix C, page 100.

PHILADELPHIA SUBURBAN GAS & ELECTRIC CO.—SCHUYLKILL RIVER

This plant, located near Cromby station about 4 miles by river above Phoenixville, at Lock No. 59 of the Schuylkill Navigation Co., was built about 1904, and belonged to the Schuylkill Valley Illuminating Co. It was constructed over an old lock chamber, which is used as a wheel pit. The hydraulic plant draws its water from the canal just above a new lock built nearer the river and discharges it below through a short tailrace.

The machinery, housed in a roomy brick building, consists of two units, geared to counter-shafts, which are belted to AC generators. One unit consists of two 45-in. turbines, under 17 ft. head, driving a 200-kw. generator, while the other comprises two 36-in. wheels, under the same head and driving a 150-kw. generator. The plant is operated as an auxiliary to the Phoenixville steam station of the Philadelphia Suburban Gas & Electric Co., which also has stations at Westchester and Pottstown. It is stated that power is entirely secondary, inasmuch as there is sometimes not enough water to make it worth while to operate.

PHOENIX WATER POWER CO.—SCHUYLKILL RIVER

The plant, just above Phoenixville on the Schuylkill River, was completed in 1914, the company having been incorporated in 1913, after approval by the Water Supply Commission of Pennsylvania. This company makes use of the Black Rock Dam and canal of the Schuylkill Navigation Co., operating under a lease from the canal company, and the station is between the canal and the river,

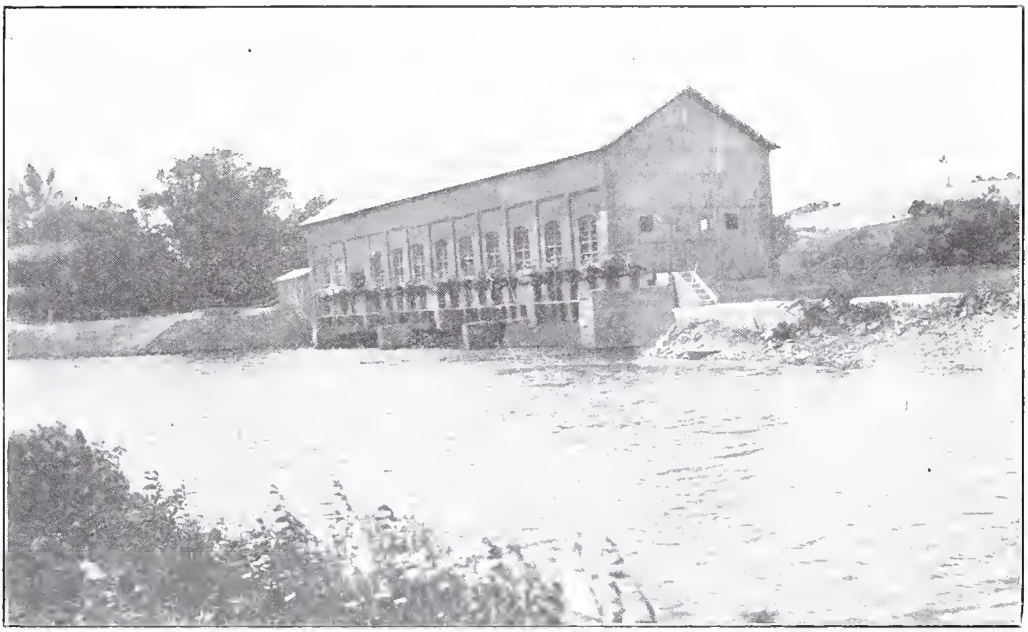


Fig. 11. Station of the Phoenix Water Power Co., Schuylkill Canal near Phoenixville

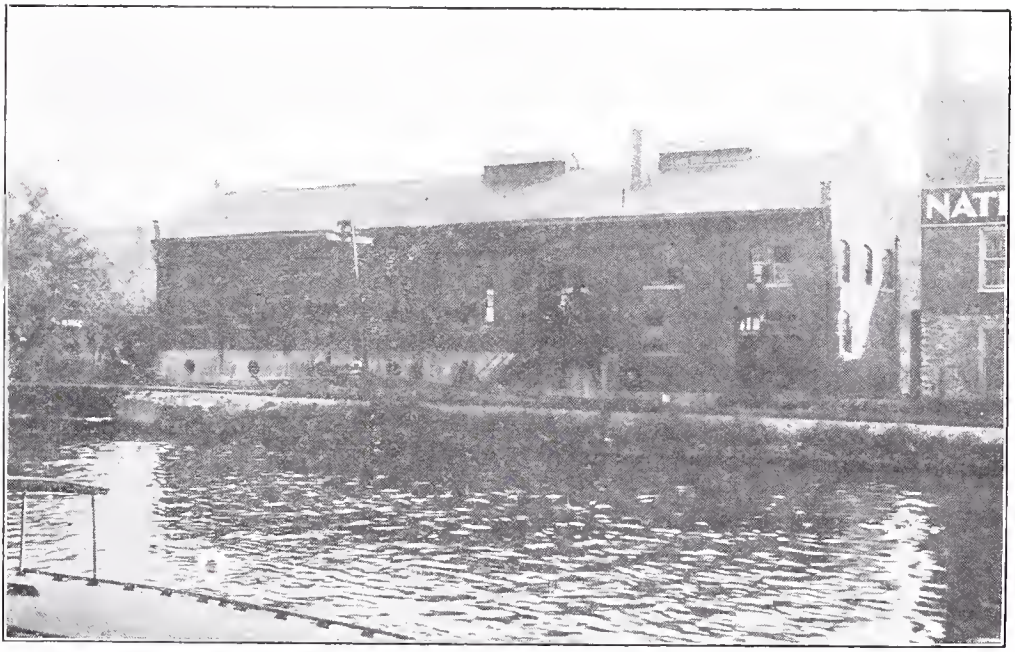


Fig. 12. Station of the Philadelphia Hydro Electric Co., Schuylkill Canal at Manayunk

about 700 feet below the dam. As canal navigation is limited, the bulk of the water is available for power. The drainage area tributary to Black Rock Dam is about 1,148 square miles.

The dam is a timber-crib structure about 375 ft. long, estimated to flood 198 acres, and backs water about 4 miles to Cromby station. The canal has been deepened and widened above the power station and is now about 100 ft. in maximum width and 10 ft. in depth.

The machinery is set in a brick and concrete building 132 ft. by 38 ft. Foundations have been constructed for two additional units, although the superstructure has not been extended to cover them. The building provides for five principal units, of which three are installed and another ordered. These, of the vertical, single-runner type, are installed in open concrete flumes and are direct connected to umbrella-type generators. The wheels are 74-in. turbines, operating at 72 r. p. m. and rated at 375 hp. under 11 ft. head. Two 100-hp. turbines of similar type, 40 in. in diameter, drive 60-kw. exciters.

Three-phase current, at 2,300 volts, is transformed to 13,200 volts, and carried to Collegeville on a double circuit. The plant has but recently been placed in operation and its market is understood to be not fully developed, but the Reading Transit Co. takes a large amount of power.

PHILADELPHIA HYDRO ELECTRIC CO.—SCHUYLKILL RIVER

This plant is at Manayunk on the canal of the Schuylkill Navigation Co. and is the largest plant in the Lower Delaware Sub-basin. It was incorporated in 1907, built in 1910, and reconstructed with rearrangement of machinery in 1914.

Manayunk is 9 miles from Philadelphia City Hall and is in Philadelphia County. The plant is about a mile below Flat Rock Dam of the Schuylkill Navigation Co., and diverts water from the canal to the river. This canal, at the point of use, is about 80 ft. wide and 10 ft. deep, although frequent dredging has been necessary to maintain this depth.

The power house is a modern brick building with concrete foundations and contains four principal units. Each consists of a double 33-in. turbine, under 23-ft. head, running at 214 r. p. m. and rated at 700 hp.; also an umbrella-type AC generator, rated at 400 kw. The electrical equipment has been installed during the past year to replace an old installation. Two vertical shaft 60-kw. exciters are driven by belt from the turbine shafts.

The tailrace is about 150 ft. long and excess water is carried from the forebay by a spillway at the end of the power house. The

concrete wheel chambers also have rollways which pass excess water to a depth of 18 in., while the draft tubes discharge underneath.

Current is supplied to the Union Traction Co., some being transformed into direct current at the station. For this purpose, two 500-kw. rotary converters, have been installed in one end of the station, while other current is transmitted at 13,200 volts to a substation 5 miles away. All power is sold to the railway company at the generating station switchboard.

UPPER NORTH BRANCH SUSQUEHANNA SUB-BASIN

In this sub-basin is included the territory draining into the North Branch of the Susquehanna River between the New York State Boundary and the mouth of the Lackawanna River, and embracing portions of Bradford, Susquehanna, Tioga, Wyoming, Lackawanna, Luzerne, Potter, Wayne, Sullivan and Lycoming counties. The basin lies, in general, northwest of the anthracite measures, and is traversed by the northerly ridges of the Alleghenies. It is too rugged for extensive agriculture and as most of the timber has been marketed, this region has few resources. It is sparsely populated and commercial development has been limited. The principal streams have low rates of fall and highly irregular flow; consequently, there are few water powers developed and only three hydroelectric plants are operating, these having an aggregate capacity of 1,300 hp. Another, near New Milford, Susquehanna County, has recently been abandoned.

SUSQUEHANNA COUNTY LIGHT & POWER CO.—SUSQUEHANNA RIVER

This company has an extensive light and power business in Susquehanna County, furnishing the towns of Susquehanna, Halstead, Great Bend, Lanesboro, Oakland, Montrose and New Milford. The system is supplied from generating stations at Susquehanna, Lanesboro and Montrose, although the last named plant will probably be abandoned shortly. The Susquehanna Station is a combined steam and hydroelectric plant of 800 hp. wheel capacity under 9-ft. head, while that of Lanesboro is a small hydraulic station. Both are on the Susquehanna River, the tributary drainage area being over 2,000

square miles. The two stations operate in parallel and the former is an excellent example of low-head hydraulic development, combined with an efficient steam auxiliary. The largest single customer is the Erie Railroad with about 700 hp. installed capacity in its shops at Susquehanna.

LOWER NORTH BRANCH SUSQUEHANNA SUB-BASIN

The Lower North Branch Susquehanna Sub-basin includes the Lackawanna River and the area draining into the North Branch Susquehanna River below, embracing portions of Luzerne, Columbia, Lackawanna, Schuylkill, Northumberland, Montour, Sullivan, Susquehanna, Wayne, Lycoming, and Carbon counties. Anthracite is mined in this basin and the cities of Scranton and Wilkes-Barre, with the large towns of Carbondale, Hazleton, Berwick, Bloomsburg and Danville, are located herein. The development of this region has been largely coincident with that of the coal fields and its industries have been operated chiefly with steam power.

The principal stream utilized for water power is Fishing Creek, which drains the northern half of Columbia County, operating three hydroelectric plants besides paper mills and a number of flour and grist mills. Coal is fairly high in price in this valley which is served by two small railroads. The only other hydroelectric plant is a small one at Wapwallopen on Big Wapwallopen Creek, although two private plants are known, and a small one at Ringtown in the watershed of Catawissa Creek was abandoned during the past year from inadequacy of water supply. Steam stations at Scranton, Wilkes-Barre and Harwood, using cheap fuel, supply the bulk of the power market and can do so at low cost. This is probably the reason that several projects on the Susquehanna and its tributaries have failed of development.

COLUMBIA & MONTOUR ELECTRIC CO.—FISHING CREEK

This company operates the Irondale hydraulic plant on Fishing Creek, although it obtains most of its power from a steam plant at Bloomsburg and by purchase from the Harwood Electric Co. It is one mile above Bloomsburg and its diversion dam, 1.5 miles farther

up stream, was first used for electric power in 1904. The plant was rebuilt in 1909, and in 1913 the dam was reconstructed under the supervision of the Water Supply Commission.

Fishing Creek has an average rate of fall of about 9 ft. per mile for the lower 12 miles of its course and its flow is variable. Its drainage area is 300 square miles at the diversion point and about 50 per cent of its watershed is cleared land, partly cultivated.

The dam is an earthen embankment about 550 ft. long and 8 ft. to 10 ft. high, with a timber-crib spillway section 760 ft. long, backing water about one mile upstream. Head gates admit water to a race about 7,300 ft. long, formed by an embankment parallel to the foot of the hillside, and the tailrace is about 1,200 ft. long. Both channels are well maintained and although long, the losses are low.

The plant has a central operating shaft, to which wheels and generators are belted and which permits interchange of machinery as required. Two wheels are 24-in. turbines, rated at 180 hp. each, under 29-ft. head, and drive two 180-kw. AC generators, producing current at 2,300 volts. A 36-in., 350-hp. turbine drives a 225-kw. DC generator, providing current at 550 volts. All the wheels are in cylindrical steel cases, connecting with a small forebay by short steel penstocks. No head gates are provided, but the wheels may be shut off by stop logs. A governor is provided for the large wheel, but the others are driven in parallel with a steam driven circuit and require no governors. The machines are not all in use at once, the maximum load on the plant being stated as 250 kw. and the normal load about 200 kw. when the stream flow is sufficient.

The alternating current is transmitted at 2,300 volts to Bloomsburg, where it is delivered in parallel with current from the company's steam plant. The direct current at 550 volts is used on the street railway lines of the Columbia & Montour Electric Railway Co.

UPPER WEST BRANCH SUSQUEHANNA SUB-BASIN

In this district, comprising portions of Clearfield, Cameron, Cambria, Elk, Potter, Center, Clinton, Indiana, McKean and Jefferson counties, no hydroelectric plants were found. The streams are little used for power and coal is cheap; in fact, coal mining is an important industry and the centers of population lie close to the mines.

MIDDLE WEST BRANCH SUSQUEHANNA SUB-BASIN

The Middle West Branch Susquehanna Sub-basin includes portions of Clinton, Center, Tioga, Potter, Lycoming and Cameron counties. The Susquehanna River here breaks through the ridges of the Alleghenies and its tributaries follow the valleys. The principal stream employed for water power is Bald Eagle Creek, Center County, which drains an area largely underlaid by limestone and has a comparatively regular flow. On this stream and its tributaries are four hydroelectric plants, while another is operated in connection with a woolen mill at Woolrich, in eastern Clinton County. The plants aggregate 430 hp. No other streams supply plants of this sort and the few water powers are chiefly flour and grist mills in the agricultural districts.

LOWER WEST BRANCH SUSQUEHANNA SUB-BASIN

This district comprises portions of Lycoming, Sullivan, Union, Northumberland, Montour, Tioga, Clinton, Bradford, Columbia, Center and Wyoming counties, and covers the region in which the West Branch enters the alternate ridges and valleys of the Alleghenies. The river itself has no water power development except a pumping station of the Lycoming Edison Co. at Williamsport. There are numerous flour and grist mills and a single hydroelectric plant on the tributaries.

EAGLESMERE LIGHT CO.—TROUT RUN

This development, in Sullivan County, is of importance as it involves seasonal regulation of the flow of the stream by storage and utilizes a high head. Most of the stream is thoroughly utilized and the bulk of the possible power developed. The first power station was constructed in 1900, but in 1907 a new power house was built one-half mile farther downstream and greater head secured.

Trout Run is a small stream, tributary to Muncy Creek at Muncy Valley, with a total drainage area of 4 square miles, practically all covered with second-growth timber. The greater part of this watershed lies high in the hills of Sullivan County and is underlaid with

sedimentary rocks. The storage reservoir drains about 1,800 acres and covers, when full, an area of 100 acres. The dam is a crib and rock-fill structure about 350 ft. long, built in 1900 and raised 3 ft. in 1904. Gates and flash-boards are placed in the spillway to regulate the stream and pond level. The reservoir capacity is said to be sufficient to operate the plant for 100 days, a draft which has been approached once in 7 years.

About 4,000 ft. below the storage dam, another rock-fill dam about 150 ft. long, provides daily pondage and an entrance to the pipe line, the bottom outlet being provided with a gate chamber. From this dam a 20-in. pipe, 8,400 ft. in length, extends to the power house and gives a static head of 502 ft.

The power house is a substantial stone building and contains two similar operating units, each including an impulse wheel, rated at 462 hp. under 489-ft. head and a direct connected 240 kw. generator producing 3-phase current. Exciters are belted to the generators and the water wheels are controlled by governors which operate deflecting nozzles, while hand-operated needle valves afford additional control. The tailrace is about 5 ft. wide and 200 ft. long.

An 11,000 volt transmission line extends 14 miles to Hughesville, where current is sold to the Citizens Electric Light & Power Co. Some current is also disposed of enroute at Picture Rocks, and Muncy Valley. The other market of importance is the summer resort of Eaglesmere, supplied by a 6,600 volt line, 6 miles long. While details of this development are not above criticism it represents a type toward which our water powers appear to tend. That it has operated successfully for 14 years without financial trouble is a strong argument in its favor.

MIDDLE MAIN SUSQUEHANNA SUB-BASIN

The portion of the drainage area of the Susquehanna River lying above the mouth of the Juniata and below the intersection of the North and West branches is included in this district, and embraces parts of Center, Union, Snyder, Northumberland, Schuylkill, Dauphin, Perry, Columbia, Mifflin and Juniata counties. The sub-basin is traversed by the ridges of the Alleghenies, lying generally in a northeasterly and southwesterly direction, and the tributaries of the Susquehanna follow the valleys between the ridges. These streams have moderate slopes, but traverse rather thickly settled communities and are utilized considerably by small mills. There are four hydroelectric plants of 820 hp. aggregate capacity, representing chiefly old mill properties.

Fig. 13. Storage Reservoir of the Eaglesmere Light Co., Hunters Lake near Eaglesmere

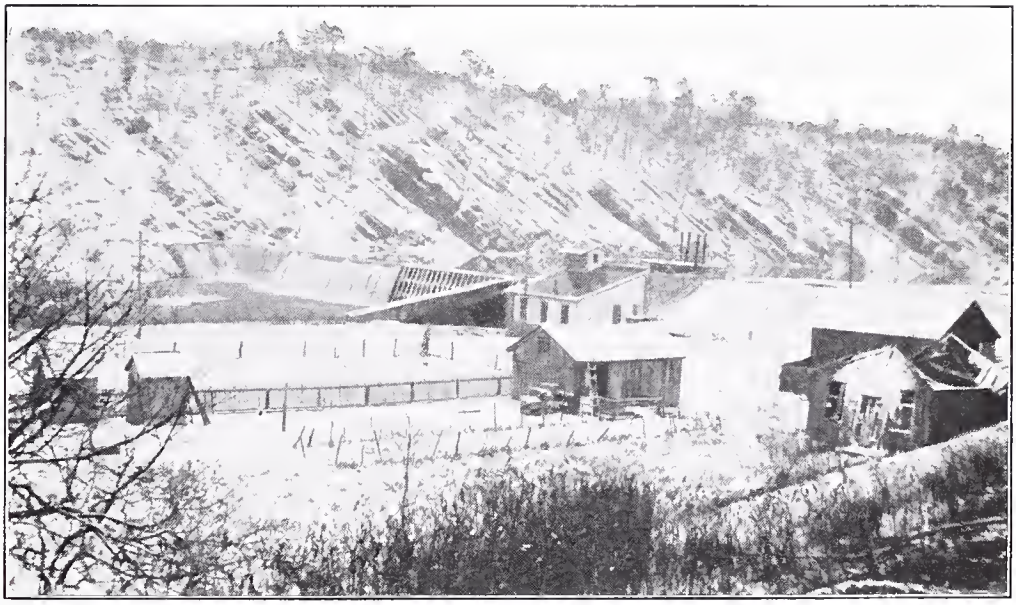


Fig. 14. Station of the Northumberland County Gas and Electric Co., Middle Creek near Selinsgrove

NORTHUMBERLAND COUNTY GAS & ELECTRIC CO.—MIDDLE CREEK

This plant is in Snyder County, about three-fourths of a mile above the junction of the stream with Penns Creek, 2 miles south of Selinsgrove and 7.5 miles south of Sunbury. It was built in 1906 below an old mill dam, the site of the old structure being submerged by the new works. The station, built by the Mill Creek Electric Co., was bought in 1912 by the Northumberland County Gas & Electric Co., which operates a steam plant at Sunbury.

Middle Creek is about 33 miles long and falls at the rate of about 8 ft. per mile in its lower course. The drainage area above the dam is about 162 square miles, of which perhaps about 50 per cent is forested. The topography is mountainous and the population scattered.

The dam is a hollow, framed-timber structure of the "Beardsley" type, with a spillway length of 100 ft. and a total length, south of the power house, of 274 ft. Flash-boards on the spillway make the top of the dam almost uniform in elevation. North of the power house is a heavy, earth fill with a 6-ft. clay core. The power house itself is of substantial construction and fills the space between these two sections of the dam.

The wheels are installed in a forebay, about 25 ft. by 40 ft., of heavy masonry walls on rock foundation, but the wheels are supported by a woden floor on steel girders.

There is one unit operating under an average head of 20 ft. There are two 33-in. turbines on the main shaft, each rated at 200 hp. under 22-ft. head and at 200 r. p. m. Both are direct connected to a 250-kw. generator, producing 2-phase current. A governor controls the wheels and a 25-kw. exciter is direct driven by a separate 18-in. turbine, running at 300 r. p. m. The tailrace is about 300 ft. long, 50 ft. wide and 6 ft. deep.

Power is transmitted at 16,000 volts to Sunbury. The maximum production of 200-kw. can be obtained during perhaps 8 months of the year. In the dry season, the plant is run about 3 hours per day during peak load, depending upon water stored in the pond.

UPPER JUNIATA SUB-BASIN

The Upper Juniata Sub-basin includes all of the drainage area of the Juniata River lying above a point just below the intersection of the Raystown and Frankstown branches. The district includes all of Blair and portions of Bedford, Huntingdon, Center, Fulton, Somerset

and Cambria counties, and covers the basins of the two branches. These drain the highly cultivated valleys of the ridges east of the "Allegheny Front," their watersheds being highly varied in character. Two hydroelectric plants, aggregating 7,900 hp., are now operating in this sub-basin, these being among the important ones in the State. The plant of the Wilson Electric Co., at Alexandria, has been recently bought out by competing interests and abandoned.

PENNSYLVANIA HYDRO ELECTRIC CO.—FRANKSTOWN BRANCH, JUNIATA RIVER

The station is at Warrior's Ridge, about 4 miles above Huntingdon, where the river cuts through the mountain ridge of that name. It is near the main line of the Pennsylvania R. R. and lies in both Porter and Logan townships of Huntingdon County. It is the third plant in the State in capacity and load, and was built by the Juniata Water and Water Power Co., which corporation was consolidated with others holding rights on the stream. It was completed early in 1907 and has since been in operation. The company suffered financial difficulties and its property was finally secured by the Pennsylvania Hydro Electric Co., which has an operating agreement with the Penn Central Light & Power Co., by which the latter administers the property. The Penn Central Co., operates a distribution system through the Juniata Valley, with steam stations at Altoona, Williamsburg and Lewistown.

The Frankstown Branch has a drainage area here of 840 square miles, of which about 25 per cent is forested. The watershed lies among the ridges of the Alleghenies and is decidedly mountainous in character. A gaging station, maintained at Huntingdon since 1895, shows that the maximum recorded discharge is 37,800 second-feet, while the minimum is 75 second-feet. The mean annual flow for 15 years is determined at 1,190 second-feet.

At the site, the width of the valley is occupied partly by the power house and partly by the spillway section of an Ambursen hollow dam, which is 375 ft. long, 57.5 ft. wide and varying in height from 22.5 to 27.5 ft. (exclusive of cut-off). Flashboards are used regularly in the summer season. The dam submerges about 160 acres and affords a daily pondage of 2 ft. to 4 ft.

Shortly after construction, a flood cut a new channel north of the power house and necessitated the construction of an additional spillway of the same type, 137 ft. long and with a crest elevation 4 ft. above that of the main spillway. North of the auxiliary spillway an earth embankment, faced on the upstream side with concrete, extends to high ground beyond the flood limit.

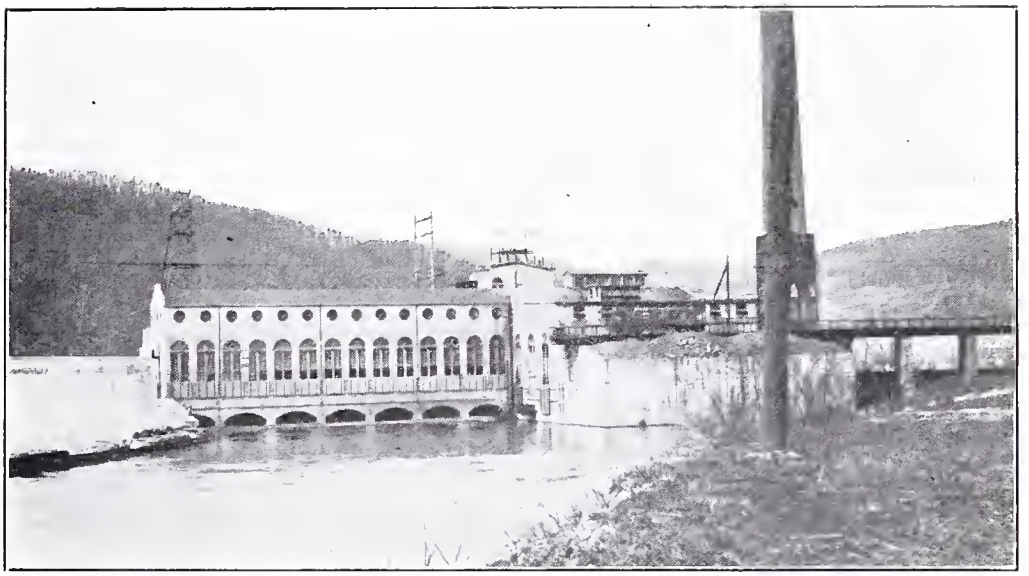


Fig. 15. Station of the Pennsylvania Hydro Electric Co., Frankstown Branch Juniata River, near Huntingdon

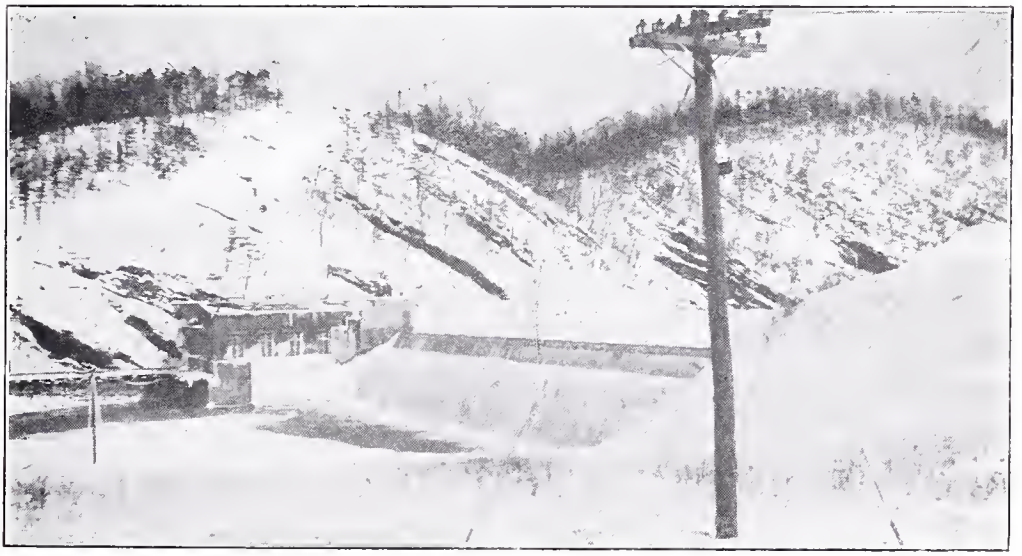


Fig. 16. Station of The Raystown Water Power Co., Raystown Branch of Juniata River

The power house is a large reinforced concrete building and contains both steam and hydraulic machinery. Four hydraulic units of horizontal, direct connected, double-runner type, operate under 27 ft. head. Each has two 39-in. wheels rated together at 1,000 hp. while the generators are of 500 kw. capacity, producing 3-phase current at 2,300 volts and 60 cycles. Excitation is provided by a turbine-driven, 75-kw. exciter. The wheels are in concrete flumes, each with its own gates and racks. Steel draft tubes, 13 ft. long, flaring from 8 ft. to 9 ft. in diameter, discharge into the tailrace. A floating timber boom is placed above the power house for protection against floating ice and drift.

The steam plant consists of two 500-kw. vertical turbines and one 2,500-kw. horizontal turbine. Hand firing is employed and noteworthy efficiency has been obtained in the boiler room.

The hydraulic plant must be regarded largely as secondary, as its annual output is a fraction of the total. In spring, when water is ample, the hydraulic plant operates under a fairly continuous load of about 2,100 kw., but at times of low water is only used for a few hours during the peak.

When the power house was built, space was left for two additional units, but a recent study of the stream flow has shown that these units would only operate for an average of 6 weeks per annum.

RAYSTOWN WATER POWER CO.—RAYSTOWN BRANCH, JUNIATA RIVER

The plant is 10 miles above the mouth of the Raystown Branch and is the fourth in size in the State, being exceeded only by the plants at Holtwood, York Haven and Warrior's Ridge. It is on a stream which has sufficient drainage area to gather large quantities of water and which does not have a steep slope; consequently, the development is typical of that possible on those streams of the State which possess similar characteristics.

The plant is in Juniata Township, Huntingdon County, one-half mile above Hawn's Bridge and is 6 miles by road from Huntingdon; 9 miles from Mount Union and about 25 miles from Altoona. The company was chartered March 30, 1906, after approval by the Water Supply Commission, construction beginning in 1908 and operation on January 1, 1914.

The river falls at the rate of about 4.25 ft. per mile, although farther upstream it increases to 6 ft. per mile. The drainage area is approximately 1,005 square miles, of which about 40 per cent is forest covered, and is largely mountainous, although several wide, flat val-

leys constitute possibly one-quarter of the drainage area. Three of these valleys are underlaid largely by limestone, but the prevailing rocks of the watershed are the palezoic shales and sandstones. The watershed lies entirely in Bedford and Huntingdon counties.

The dam consists of a 400-ft. spillway section of cyclopean concrete, a 250-ft. earthen embankment and a bulkhead section, about 180 ft. long, the latter forming one side of the forebay and power house. The spillway, about 35 ft. above the old bed of the stream, has a maximum height of cut-off of 48 ft., the section being unusually ample. It is built with a stepped surface, to lessen impact, and has also a ventilating system to maintain atmospheric pressure under the nappe of the water.

The earthen embankment section has a concrete core wall about 4 ft. thick, which extends 3 ft. into the foundation rock. This embankment has a paved slope of 1 on 2.5 on the upstream side, while the downstream slope is 1 on 1.5. In addition, all extra spoil from the dam excavation was placed on the downstream side of the embankment.

The 600-acre reservoir provides ample pondage and some seasonal storage. Flash-boards installed during the past season increased the available storage by 1,000 acre-feet. A steam turbine auxiliary of 500 kw. capacity will be necessary to carry part of the load during the dry season as the market develops, and is under construction near Williamsburg.

The power house is of heavily reinforced concrete with some brick work near the top. The forebay and water channels, except the steel draft tubes, are also of reinforced concrete. Water enters the forebay through submerged openings in the bulkhead, which give a satisfactory protection against ice. During the winter of 1912, when the temperature fell to 40 degrees below zero and about 2 ft. of ice formed on the pond, there was no ice trouble.

The hydraulic equipment consists of three direct connected horizontal units operating normally under 34-ft. head. The minimum head under which the plant is operated during low water is 28 ft., while 25 ft. has been observed under flood conditions. Two units are pairs of 42-in. wheels with a common discharge and rated at 1,500 hp. Another unit of 900 hp., consists of two 36-in. wheels of the same make, mounted in like manner. The larger wheels operate 1,000-kw. generators, while the smaller ones drive a similar machine of 625 kw. capacity. Three-phase current is produced at 2,400 volts and 60 cycles and two 45-kw. exciters are driven by a Morse chain from the larger generators.

Current is transmitted 8 miles to Mount Union and Mapleton at 2,400 volts and 13 miles to Huntingdon and Williamsburg at 22,000

volts. Near Huntingdon is a 450-kw. sub-station and another of 600 kw. at Clover Creek, near Williamsburg. This company, engaged in the manufacture and general distribution of power and electric light, supplies the towns of Huntingdon (population 7,000), Mount Union (4,000), Williamsburg (1,700) and Mapleton (700).

LOWER JUNIATA SUB-BASIN

This includes the Juniata watershed between the mouth of the river and that of the Raystown Branch, and embraces portions of Mifflin, Huntingdon, Juniata, Perry, Fulton, Franklin, Snyder and Center counties. No water power is developed on the main stream, which is followed by the main line of the Pennsylvania R. R. Two hydro-electric plants, aggregating 536 hp., are on Kishacoquillas Creek which enters the Juniata at Lewistown. In addition the plants in the Upper Juniata Sub-basin supply some power to this region.

YEAGERTOWN WATER POWER CO.—KISHACOQUILLAS CREEK

This plant is at Yeagertown, in West Perry Township, Mifflin County, about 4 miles above the mouth of Kishacoquillas Creek and about 3 miles from Lewistown, at an old mill site which, in 1908, was taken over by the water power company, the existing dam and races reconstructed and enlarged and an entirely new power plant constructed.

Kishacoquillas Creek has, at this point, a drainage area of 185 square miles, chiefly in the valley west of Jack's Mountain and largely underlaid by the Trenton Limestone. The records of the gaging station at Culp's Mill, just above Lewistown, maintained by the Commission, show the dry season discharge to be fairly well sustained.

The dam is a spillway structure about 90 ft. long, 12 ft. high and 30 ft. wide. It was originally a timber crib founded upon the creek bottom, and when reconstructed the faces were covered with concrete slabs, so that it now has the appearance of a concrete structure. At the westerly end are substantial concrete headworks which admit water to an earth canal about 25 ft. wide, 1,200 ft. long and 4 ft. to 8 ft. deep. The canal is crooked, following the foot of the hillside, and connecting, through 300 ft. of concrete arch culvert, with a small

forebay whence water passes through short steel penstocks to concrete wheel chambers. The entrance to these pipes is controlled by head gates and a waste gate at the end of the forebay allows surplus water to escape into the tailrace, which is another earth canal about 200 ft. long and 30 ft. wide.

The power house is of substantial concrete construction and contains two units, operating under a head of 18 ft. to 20 ft. Two 26-in. double runner turbines of 500 hp. total capacity, are direct connected to a common counter-shaft, to which are belted two 150-kw. generators, delivering 3-phase current. Current is transformed at the station to 6,600 volts for delivery to the Penn Central Light & Power Co's. sub-station at Lewistown. The transformation equipment, however, is the property of the latter company which through its subsidiary, the Mifflin County Gas & Electric Co., purchases the entire output.

LOWER MAIN SUSQUEHANNA SUB-BASIN

In the Lower Main Susquehanna Sub-basin occur most of the hydroelectric developments of the State, comprising 27 plants under 22 ownerships. Their aggregate capacity is 147,982 hp., or 85.6 per cent of the whole. The district is, therefore, the hydroelectric center of Pennsylvania, and its peculiar features are worthy of close study.

The sub-basin includes that portion of the drainage area lying between the mouth of the Juniata River and the Maryland line, and includes all of York and portions of Lancaster, Cumberland, Dauphin, Lebanon, Perry, Adams, Chester, Schuylkill, Franklin and Berks counties. The cities of Harrisburg, York, Lancaster and Lebanon are within its borders; of these Lebanon is the only one not supplied by hydroelectric power. The sub-basin includes the most highly developed agricultural regions in the State, only a small portion on the northern edge being mountainous and unsettled. Industries of importance offer a ready market, and the populous territory insures a heavy demand for lighting.

The developments are of two classes. The two largest plants, at Holtwood (McCall Ferry) and York Haven, are on the Lower Susquehanna, which falls 315 ft. between Harrisburg and the Chesapeake Bay. With its enormous drainage area of 26,000 square miles, the river delivers large volumes of water, capable of utilization under low or moderate heads. Such developments require heavy construc-

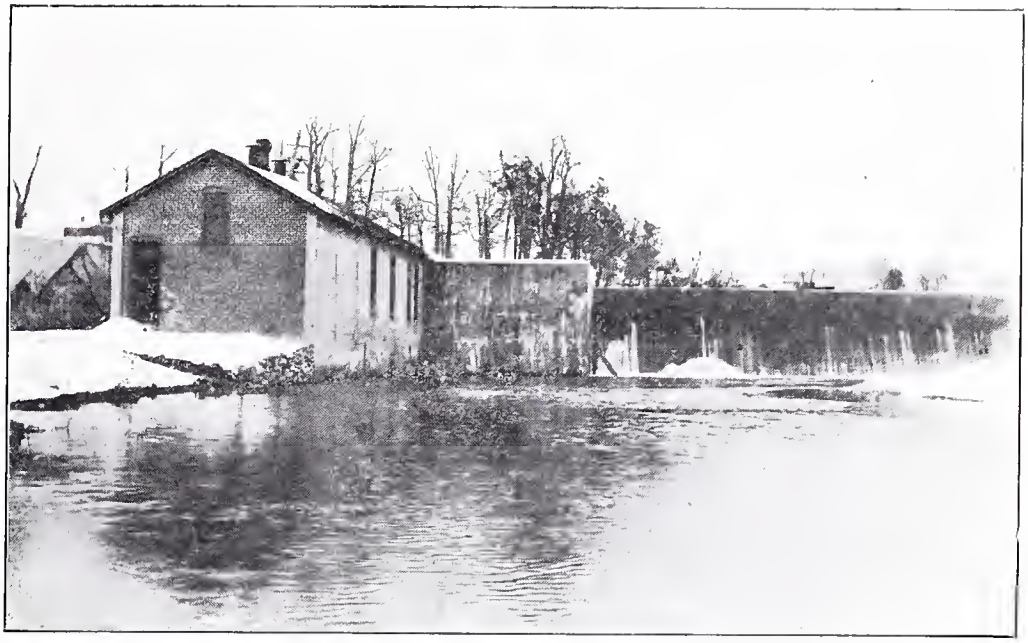


Fig. 17. Station of the Yeagertown Water Power Co., Kishacoquillas Creek above Lewistown

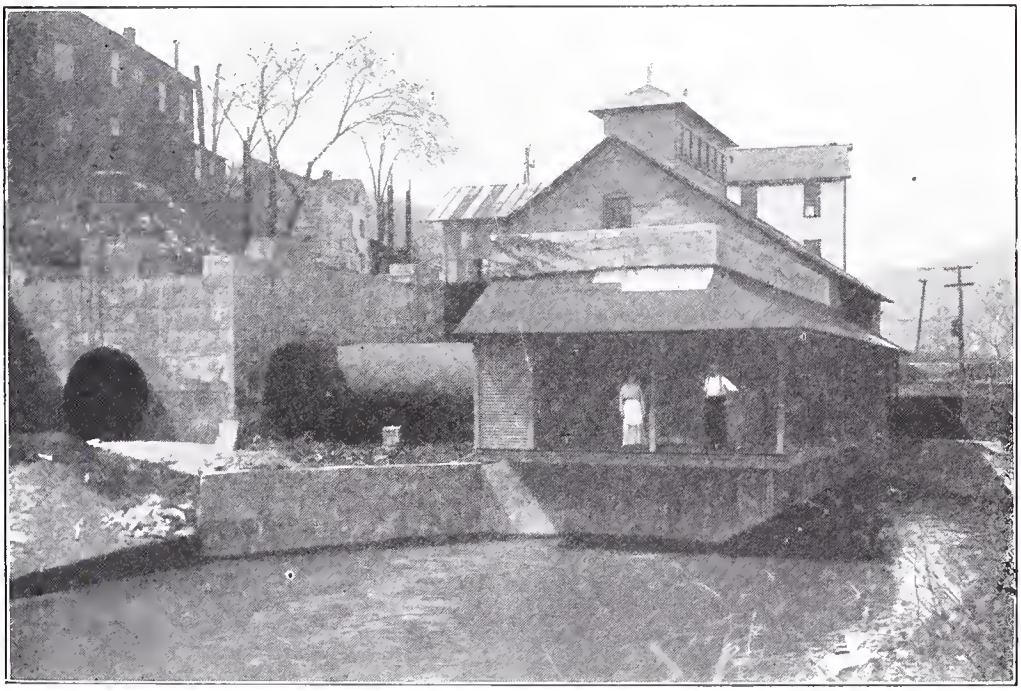


Fig. 18. Station of the Shippensburg Gas and Electric Co., Mill Spring Creek, near Shippensburg

tion costs and a steam reserve to meet deficiencies during seasons of low flow, but have enough water during the greater part of the year to produce current at a low unit cost.

The other class of plants includes chiefly small developments on Conodoguinet, Yellow Breeches, Conestoga, Pequea and other creeks. These streams are all of moderate slope, but drain territory underlaid to some extent with limestone. They have a heavy spring-water supply, persistent during the dry season, and their discharges are comparatively regular. This is especially true of Yellow Breeches Creek, which drains portions of York and Cumberland counties.

These several causes have contributed to hydraulic development in this region, and there is apparent opportunity for further additions. Only about 80 ft. of head on the Lower Susquehanna below Harrisburg are developed while over 200 ft. available yet remain. The limestone streams also are only partly developed, and the smaller towns offer markets for hydroelectric service.

SHIPPENSBURG GAS & ELECTRIC CO.—CONODOGUINET CREEK

This company conducts a gas and electric power business at Shippensburg, Pa., and its works include a gas generating outfit, a steam plant and three hydraulic plants. An additional water power plant is under construction, and another contemplated. This business was first incorporated as the Shippensburg Gas Light Co., which with the Southampton Light, Heat & Power Co. and the Middle Spring Light, Heat & Power Co., formed the Shippensburg Gas & Electric Co., on February 29, 1904.

Two of the hydraulic plants are close together on a tributary of Conodoguinet Creek, variously known as Branch Creek, Mill Spring Creek and Means Run, about 2.5 miles north-northeast of Shippensburg. These plants have wheels of 170 hp. capacity under small heads.

The third plant is on the main creek about one mile below Roxbury, and is the largest of the system. The drainage area of the stream is about 40 square miles, of which about 50 per cent is forested. A long headrace and dam constitute a continuous structure about 3,000 ft. long and of this, 210 ft. is spillway, discharging into the old creek channel. The headrace portion is a concrete wall backed in places by buttresses and elsewhere by earth fills. The power house is substantially constructed of concrete and contains one horizontal unit, a single runner 35-in. turbine, rated at 350 hp. under a head of 25 ft., direct connected to a 250-kw. generator, producing 3-phase current.

The output of the system is used in Shippensburg, and supplies the general light and power market of this vicinity. A steam plant which carries the load after 10.00 p. m. is used in connection.

CARLISLE LIGHT, HEAT & POWER CO.—CONODOGUINET CREEK

About one mile north of Carlisle, the Carlisle Gas & Water Co., and its subsidiary, the Carlisle Light, Heat & Power Co. (incorporated October 2, 1911), have a joint plant to pump water for the Borough of Carlisle and to generate electric current. The site has been in use for at least 150 years, being one of the oldest mill sites in Pennsylvania. The pumping plant was built in 1883, and the electric plant installed in 1913. The drainage area is 342 square miles and is mostly in the farming country of the Cumberland Valley, though the steep ridges on the north side form a considerable part of the watershed.

When the electric plant was built the headrace and tailrace were enlarged and improved, new gates, racks and other accessories provided and other improvements effected, but the dam, which had been rebuilt about 1908, was not changed; it is of stone masonry curved slightly upstream and approximately 325 ft. long.

The headrace is about 600 ft. long, with vertical concrete side walls and a concrete floor for a portion of its length. The loss of head is slight and a capacious forebay just above the headrace has racks and steel gates. The tailrace is about 400 ft. long, half of it joins the power house and has concrete walls, the balance is entirely in earth.

The seven turbines have 53-in. runners on vertical shafts, and are rated at 55 hp. under 8-ft. head. Five are connected by rope drive to one jack-shaft and two to another jack-shaft. The former drives a 200-kw. AC generator; the latter is connected by gearing to a duplex pump which lifts 2,000,000 gallons per day against 100 ft. head. There is in reserve a large steam pump with boiler.

It was stated that the pumping plant could be run by one wheel and that there was always sufficient water for this. The electric plant supplies auxiliary power for the main steam generating station of the company in Carlisle. This station, of 1,800 kw. capacity, is well arranged and equipped.

YORK HAVEN WATER & POWER CO.—SUSQUEHANNA RIVER

This plant, at the Borough of York Haven, on the west bank of the Susquehanna River, is the second largest hydraulic station in the State. It is about 13 miles from York and 15 miles below Harrisburg and supplies power to both cities.

The company was incorporated January 16, 1895, for the supply of water and power to the public in the Borough of York Haven and construction was begun about 1901. It was nearly completed in

Fig. 19. Station of the York Haven Water and Power Co., Susquehanna River at York Haven

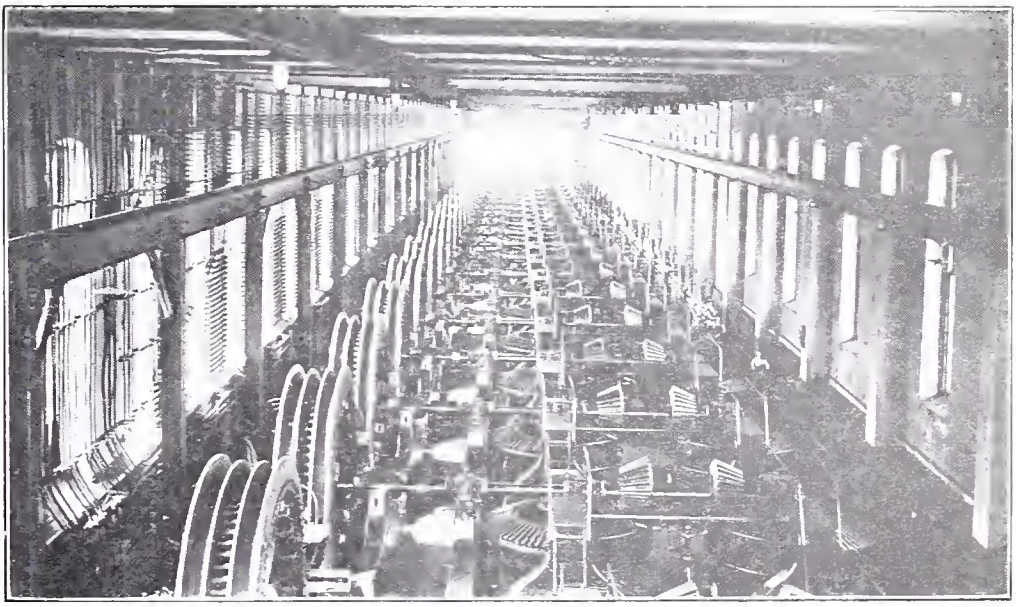


Fig. 20. Generator Room of the York Haven Water and Power Co.

March, 1904, when a heavy ice flood wrecked the power house and necessitated reconstruction. The plant was placed in operation September, 1904, with 10 units, which number has since been doubled.

The power site is at Conewago Falls, where the river has a descent of about 23 ft. over a series of rapids within a distance of three-quarters of a mile. This rate of fall exceeds the general slope of the river, which is about 5 ft. per mile, both above and below the falls. The site was previously used by the York Haven Paper Co., which still holds a preferential right to a portion of the water. Its mills adjoin the power station and draw water from the race.

The drainage area of the Susquehanna at the diversion point is about 25,000 square miles, and the mean annual flow about 40,000 second-feet. The best hydrographic records available are those from the gaging station at Harrisburg, which indicate a maximum of 700,000 second-feet in 1889 and a minimum of 2,330 in 1900. The York Haven plant has machinery to utilize about 12,000 second-feet.

Just above Conewago Falls is a large island known as Three-Mile Island, and the principal channel of the river is on the west side of this. A long diversion dam extends from the island diagonally across and down the stream to the headrace. The power house lies parallel with the shore, and water passes through it from the headrace directly into the river below the rapids. The channel east of the island is open at present and a certain portion of the stream flow is not available.

The diversion dam is about 3,300 ft. long. A length of 1,400 ft. was built prior to 1904, extending part of the distance from the headrace to the island. This was a timber-crib structure resting upon bed rock, and has since been reinforced on the lower side with a heavy concrete wall. After the plant was in operation, the dam was extended to the island and this portion of the structure, built of stones and boulders, was covered both upstream and downstream with concrete. This arrangement completed the diversion of the water in the west channel during low stages. Most of the dam is quite low, especially the newer construction, and the older portion probably does not exceed 16 ft. in maximum height. The headrace, about 3,000 ft. long, is formed by a heavy masonry wall parallel with, and about 500 ft. from, the west shore. The wall varies in height from 18 ft. to 39 ft. and is of substantial masonry, chiefly large blocks of trap rock laid in Portland cement mortar. It has received severe treatment from ice and other floods without material damage.

The power house is a brick structure upon concrete and masonry foundations, 450 ft. by 50 ft. and contains 20 generator and 2 exciter

units. Each main unit consists of two vertical-shaft turbines, geared to a horizontal shaft, which is coupled direct to an AC generator of the induction type. The turbines, built after designs of the Escher-Wyss Co. of Switzerland, are 78.5 in. in diameter, rated at 613 hp. under 22 ft. head and 80 per cent gate, and at the same power under 19 ft. head and full gate. The generators are of 750 kw. each and produce current at 60 cycles and 2,300 volts. The wheels are mounted in a concrete flume, with a rectangular, hand-operated steel gate at the entrance, and vertical steel draft tubes lead to tail-water. Each exciter is driven by a single 62.5-in. turbine rated at 415 hp. under 22 ft. head and 80 per cent gate.

This plant has suffered great damage from ice. Anchor ice has occasionally choked the turbines and more frequently floating ice has clogged the headrace so as to diminish the available water. A continuous set of racks, formed of heavy steel bars, keeps floating ice out of the wheel chambers and also catches drift and trash. The heavy masonry wall terminating the headrace and connecting the power house with the shore, has no effective spillway and floating ice is pocketed between the power house and the shore. This condition resulted in the practical demolition of the power house in 1904, and a spillway for the passage of ice is under consideration.

Operation is controlled from switchboards above the generating floor and supported by the roof trusses. From the switchboard the current passes through cables in a gallery over the boundary wall to the transformer house on the shore. Here the voltage is stepped up to about 22,000 for transmission to Harrisburg, Middletown, Steelton and York. Some current is supplied locally direct from the switchboard and a small line supplies the village of Mt. Wolf about 4 miles distant. Control is secured by compensating governors applied to 9 of the 20 units, the others are hand-regulated according to directions of the operator.

The principal market is in and around the city of York, where are supplied the Edison Light & Power Co., the Merchants Electric Co. and the York Railways Co. In addition, there is a large commercial load, mainly in York. Under agreement, the Edison Light & Power Co. maintains a steam plant of sufficient capacity to supply auxiliary power during low water.

LANCASTER COUNTY WATER & POWER CO.—CONESTOGA CREEK

This company has three plants on Conestoga Creek, between the city of Lancaster and the mouth of the creek, all in Lancaster County. These plants are operated together and wholesale power to the Engleside Station of the Edison Electric Co. of Lancaster. The plant

farthest upstream is at Wabank, an old mill site, about 11.5 miles above the mouth of the creek. The second and largest plant is at Slackwater, 5.2 miles below Wabank and 6.3 miles above the mouth of the creek. The third, at Rock Hill, is 3.4 miles below Slackwater, and about 3 miles above Safe Harbor at the mouth of the creek.

The country drained by Conestoga Creek is rolling agricultural land, less than 10 per cent of which is wooded. The drainage area is 393 square miles at Wabank, 397 square miles at Slackwater and 398 square miles at Rock Hill, and most of it is underlaid by limestone.

The use of Conestoga Creek is very old. On March 17, 1806, an Act of Assembly provided for the use of the stream for slack-water navigation by the Conestoga Lock & Dam Navigation Co. On March 3, 1825, an Act of Assembly provided for similar use of the stream by The Conestoga Navigation Co. The latter company was sold at Sheriff Sale and an Act dated April 1, 1837, provided for reorganization as the Lancaster & Susquehanna Slackwater Navigation Co., which transported barges between Lancaster and the Susquehanna River. This company constructed a short canal at Slackwater, now used as a headrace for the power plant, and utilized dams existing at the time of the grant.

Navigation continued until 1862, when the canal property was sold by the sheriff to Edward Coleman. After passing through various ownerships, the canal rights and property were acquired by the Lancaster Electric Light, Heat & Power Co. which was incorporated February 2, 1897, and began operations on this creek in the same year. At first, power was supplied for arc lighting in Lancaster, but later, after contracting to supply power to the Edison Electric Illuminating Co., the plants were rebuilt and refitted. In 1913, the owners of the power sites were granted charters for water power companies. The Buchanan Water & Power Co. was chartered May 13, 1913, for Lancaster Township, having its source of supply at Wabank Dam. The Lafayette Water & Power Co. was also chartered May 13, 1913, for Pequea Township, using the same point of supply. With the source of supply at Rock Hill Dam, the Hamilton Water & Power Co. was chartered May 13, 1913, for Manor Township, and the Stevens Water & Power Co., for Conestoga Township, on the same date. The Lancaster County Water & Power Co. was chartered June 9, 1913, for Lancaster County, its source of supply being the Slackwater Dam. This company was intended to be a holding company through which the several companies would be merged.

The crest of the Wabank Dam is at elevation 219.0 ft., that of the Slackwater Dam at 210.4 ft. and that of the Rock Hill Dam at 194.4 ft. The tailrace of the Rock Hill plant is ordinarily at elevation

185.0 ft. These figures give differences of 8.6 ft., 16.6 ft. and 9.4 ft., a total of 34.0 ft., practically all of which is utilized.

These plants do not have steam auxiliaries and their output in the dry season is low. Each handles load in proportion to its head, approximately the same quantity of water being used in each. Power is delivered under a contract which calls for no guarantee, but the distributing company takes all the plants can supply.

WABANK PLANT

This plant, about 3 miles south of Lancaster, was first built in 1901, as an arc lighting plant, a new set of wheels being installed in 1904.

The dam is a timber-crib structure, founded on rock, 280 ft. in length and about 15 ft. in maximum height above foundation, backing water about 3.4 miles to the Second Lock Mill site. The plant has no headrace, but has a large triangular forebay, formed by a heavy masonry wall and four steel gates operated by a chain hoist on an overhead track.

The plant operates normally 18 hours per day and consists of three 48-in. wheels and one generator. The turbines, rated at 80 hp. each, are mounted with vertical shaft in an open flume and are geared to a horizontal jack-shaft. The 175 kw. AC generator is belted from this shaft, and a 6-kw. exciter is provided, as is also an oil system governor.

The transmission distance to Lancaster being only 3 miles, the generator voltage of 5,500 is employed, the maximum output being 240 kw. This plant, except for the gearing and belting features, is well designed and appears to be giving satisfactory service.

SLACKWATER PLANT

This plant is built at the lower end of the short section of canal used in the days of navigation. The first modern plant was built in 1897 for the production of arc lighting current, and was rebuilt in 1910 in a more substantial manner.

The dam is a timber-crib structure about 335 ft. long, and has sluice gates at its southern end to lower the pond to 7 ft. below the crest. The water is backed to the Wabank plant, 6.4 miles above, and the elevation of the pond surface affects the head available at Wabank. Pondage is used to the extent of 3.5 ft. when enough water flows to refill the pond over night.

The old canal is utilized as a headrace and is provided with mechanically-operated steel head gates, and two substantial timber cribs for ice protection. The headrace is about 1,300 ft. long and has the section to which navigation canals were commonly built.

The plant consists of one direct connected unit comprising a generator and four 42-in. turbines, all on one horizontal shaft. The turbines are mounted in pairs at either end of the generator shaft, and either pair may be disconnected. Each wheel is rated at 250 hp. while the generator is a 3-phase machine of 750 kw. Two turbine driven exciters are also provided.

The capacious water channels are of concrete, except for short draft tubes, and tail-water discharges directly into the stream. Racks, at the head gates of the canal and the entrance of the water channels, catch trash and ice, and the plant is provided with a governor, motor driven drainage pump, air compressor and other auxiliary machinery. Power is transmitted at the generator voltage of 5,700 to the Engleside Station of the Edison Electric Illuminating Co. of Lancaster.

This plant is well designed and maintained under intelligent management. Its head of about 16 ft. is well utilized and the machinery arranged to meet the variable flow of the stream.

ROCK HILL PLANT

This station is 3 miles above the mouth of Conestoga Creek, and near enough to the Susquehanna to be affected by backwater from the Holtwood Dam at times of high discharge. It is 3 miles from the Columbia and Port Deposit line of the Pennsylvania R. R. at Safe Harbor, and 9 miles from Lancaster. The plant was first built in 1897, remodeled in 1904 and entirely reconstructed in 1910 along novel lines.

The dam is a timber-crib structure, 240 ft. long and 12 ft. in maximum height. It is stated to be on rock foundation and backs water nearly to the Slackwater power house. A short headrace 200 ft. long is formed by a masonry wall parallel to the hillside and is provided with steel head gates, operated by overhead chain blocks.

The turbine installation is unique in that the wheels are placed in a deep pit, excavated in solid rock about 28 ft. below tail-water. Two vertical wheels drive a generator, the revolving field of which is extra heavy to secure fly wheel effect, the whole being supported on an oil thrust bearing. Headwater is admitted to the pit from the race through racks and each wheel has a separate concrete outlet. A large reinforced concrete gate, weighing about 40 tons, can shut off tail-water from the wheel pit, and electrically driven pumps are provided to drain the pit.

The two turbines are 72-in. diameter, each of 225 hp. capacity and the 350-kw. generator furnishes 3-phase current at 5,700 volts. A small exciter is also provided, driven by two 21-in. turbines on a vertical shaft.

Power is transmitted at 5,700 volts to the same station supplied by the other power plants, the distance in this case being 9 miles. The station is well designed, uncommonly well lighted and capacious and meets the conditions of low head and variable flow in an efficient manner.

COLEMANVILLE WATER & POWER CO.—PEQUEA CREEK

This plant is at an old mill site at Colemanville, Lancaster County, about 2.5 miles above the mouth of the creek, the stream forming the boundary between the townships of Conestoga and Martic. It is a combined steam and water station, used principally to supply power for the Lancaster and York Furnace Street Ry. Co., which owns a line extending from Millersville to Pequea and supplies light in the village of Pequea. The present plant was built in 1905, and until 1911 was owned by local parties, who sold power to the railway company which now owns and operates it.

Pequea Creek here flows through a narrow alluvial valley between steep hills and at the site of the plant, has a drainage area of 148 square miles. The topography is generally rolling in character, the watershed lying largely in good farm land underlaid with limestone.

The dam is a rock-filled timber-crib structure, backed with earth on the upstream side to a slope of 1 on 2. The reservoir, 1.1 miles long, has silted up so as to be almost entirely filled and 20-in. flash-boards are used to secure pondage and head. The headrace is about 450 ft. long, formed by an embankment parallel with the hillside; the tailrace, of about the same length, is lined with masonry on the sides for one-half its length and is in fair condition. Under light load and with flash-boards, the operating head is 30 ft., but under average conditions, 28 ft. is obtained, the minimum being 23 ft.

The hydraulic plant consists of two 30-in. wheels on a single horizontal shaft, developing together 550 hp. under full head. They are belted to a 425-kw. AC generator which in turn operates a 17-kw. exciter. The water channels are of riveted steel, the penstock being 6 ft. diameter and the draft tubes flaring from 4 ft. to 5 ft. diameter.

The steam auxiliary includes one 600-hp. engine, with condenser, and one 400-kw., 3-phase, 11,000 volt generator. There is also in reserve a 300-kw. DC generator. The steam plant is run alone about 3 months of the year, in conjunction with the water plant about 3 months, while the latter operates alone during the remainder.

When the water plant is in service, the current is stepped up to 11,000 volts. Both at a sub-station, 7 miles east, and at the power house are installed 250-kw. rotary converters. When the steam plant is used, current is generated at 11,000 volts direct.

PENNSYLVANIA WATER & POWER CO.—SUSQUEHANNA RIVER

This development is at Holtwood, about one-half mile below McCall Ferry, and 26 miles above the mouth of the river. It is the largest hydroelectric plant in the State, and supplies power to Baltimore, 40 miles south, and Lancaster, 15 miles north. It is reached by the Columbia & Port Deposit Branch of the Pennsylvania R. R., which follows the east bank of the Susquehanna from Columbia to the mouth.

The importance of power possibilities in this vicinity have long been known, and numerous charters have been obtained by corporations aiming to develop the power. All of these active at the time were taken over by the McCall Ferry Power Co., incorporated in 1905, which also bought the real estate and rights of the Columbia & Tidewater Canal (an abandoned waterway), so far as these affected the project, and began construction in October, 1905. In the financial panic of 1907, this company went into the hands of receivers and construction ceased, but in the fall of 1908 was resumed by the receivers. The company was subsequently reorganized as the Pennsylvania Water & Power Co. and now operates the plant which is not yet completed, although power delivery began from one unit in October, 1910. Eight of the projected ten units are now in operation, the last having been installed late in 1914, and the others will be installed as the power demand increases.

The Susquehanna at the point of development flows through a narrow valley, bordered by steep hills. It has a rate of fall of 5.4 ft. per mile, much greater than the average of the river. Another feature of the site is the presence of islands in the river which lowered the cost of dam and tailrace construction.

The drainage area at Holtwood is approximately 26,770 square miles. The topography of the basin is that characteristic of the State as a whole, being divided between highly cultivated, rolling country, and mountainous regions from which most of the timber has been removed, leaving only second-growth and scrub. The rate of population is approximately 100 per square mile, the cities of Binghamton, Elmira, Scranton, Wilkes-Barre, Williamsport, Harrisburg, York and Lancaster being within the limits.

The record of stream flow is unusually complete, though obtained largely by indirect methods. Gage readings at Harrisburg have been maintained continuously since 1891, and these discharges multiplied by 1.114 (the ratio of the respective drainage areas), have given the most satisfactory figures for the stream flow at Holtwood. The maximum flood of approximately 700,000 second-feet occurred in June, 1889, and the minimum flow of 2,600 second-feet in September, 1900.

The maximum discharge used up to the present by seven units has been 18,000 second-feet. At present the average consumption is about 10,000 second-feet, but with all the units installed it is expected that an average peak consumption of 24,000 second-feet will be reached when this quantity is available.

The dam is a monolithic spillway structure, of ogee section, built of 1: 3: 5 concrete with a small proportion of "plum" stones, and placed on solid rock, the foundation being gneiss with streaks of quartz and schist. The width at base is 65 ft. and the maximum height is 65 ft., although the average height in the channel is 55 ft. and is materially diminished over Fry Island. The crest elevation is 165.0 ft. and the length of the crest 2,368 ft.

The dam floods 3.95 square miles, with the pool at elevation 165.0 ft., while at elevation 169.5 ft., to top of flash-boards, the area submerged is 4.77 square miles. Elevation 160.0 ft. is taken as the lower limit of pondage, and the storage between that elevation and 165.0 ft. is computed to be 614,000,000 cubic feet; while between 165.0 and 169.5 ft. it is 1,047,000,000 cubic feet, which would supply 12,100 second-feet for 24 hours. The storage possibilities are practically limited to the daily regulation of flow in dry seasons. The backwater extends to the valleys of the Conestoga and Pequea creeks, and the power plants on these streams are said to have felt its influence at times of heavy flood.

The plant has no headrace, but has a large forebay, which is chiefly of value as a feature of the protection against ice troubles.

The power house is a massive concrete structure, placed at an angle of 42 degrees with the axis of the dam, its dimensions being about 500 ft. by 200 ft. The principal parts are the gate house, the generator room and the transformer house, the last being largely occupied by switches and offices.

In the generator room are eight units, operating under 54 ft. head, with the pool elevation at 165.0 ft. All are double runner, vertical shaft turbines except the eighth unit. Five have runners 105.5 in. diameter and operate at 94 r.p.m., each wheel being rated at 13,500 hp. under 53-ft. head. The sixth and seventh have runners of 97.5 in. diameter and are rated at 17,000 hp. under 62-ft. head. The eighth unit has a single runner and is rated at 16,500 hp. under 63-ft. head.

Nos. 1, 2 and 3 generators are of 7,500 kw. capacity; Nos. 4 and 5, of 10,000 kw., while Nos. 6, 7 and 8 are rated at 12,000 kw., all generating 3-phase current at 11,000 volts and 25 cycles. Two exciter sets, each of 750 kw., are driven by water turbines of 1,000 hp., and there is also one motor-driven exciter of 500 kw. capacity, all operating at 240 r.p.m. and 250 volts. Thorough provision for excitation has been made, largely in anticipation of ice troubles.

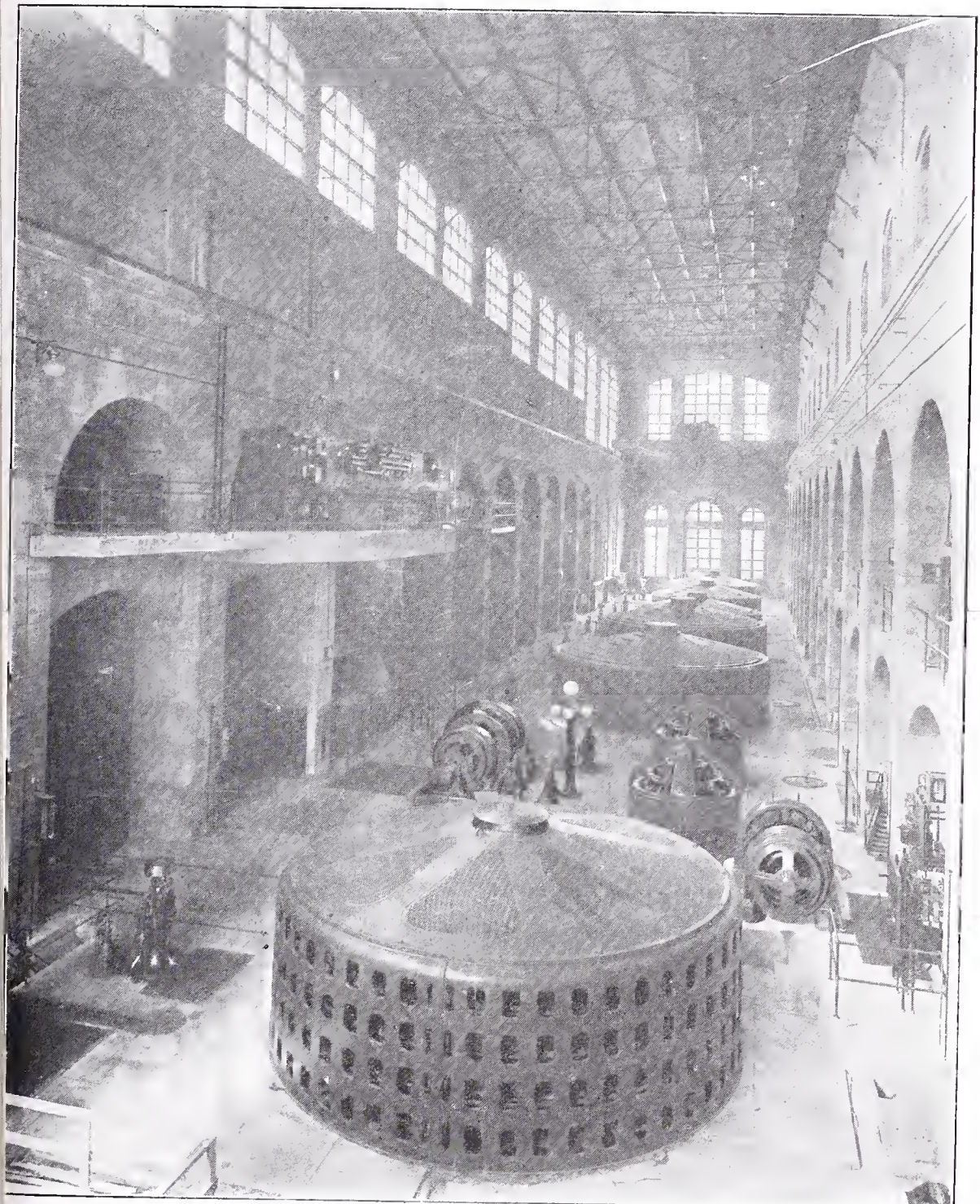


Fig. 21. Generator Room, Pennsylvania Water and Power Co., Susquehanna River, Holtwood

The plant has unusually good ice protection. The upstream end of the forebay is formed by a rock fill extending out from the shore 500 ft., downstream from the end of which is a floating timber boom with a vertical face 5 ft. deep; this is 240 ft. long and is supported at the ends by two massive concrete piers. Between the boom and the junction of the dam and power house are three submerged masonry arches through which water enters the forebay, these being so proportioned as to limit the velocity through them to 4 ft. per second. No floating ice has ever passed into the forebay from the river, but should this occur, provision is made for its disposal by three ice chutes at the shore end of the power house. To prevent ice from entering the screen room, submerged masonry arches are provided along the entire length of the building; such ice and debris as passes this skimmer can be discharged through two ice chutes within the limits of the structure. The latter has never been used for the passage of ice and the former only to dispose of ice formed in the forebay.

The tailrace, 150 ft. to 250 ft. wide, and about three-quarters of a mile long, was formed by deepening the natural channel east of Piney Island and necessitated the removal of about 150,000 cubic yards of material. A wall from the junction of the dam and power house downstream to Piney Island closes the upper end of this channel.

Three-phase current is transmitted at 70,000 volts to Baltimore and Lancaster. An additional tower line to Baltimore, parallel with the original line, is under construction. Elaborate protection against lightning has been made.

The present customers are the Baltimore Consolidated Gas, Electric Light & Power Co., the United Railways & Traction Co., of Baltimore, and the Edison Electric Co., of Lancaster. All these have steam power available for use when low stream flow seriously curtails the output of the plant.

DELTA ELECTRIC POWER CO.—MUDDY CREEK

This plant was built about 1896 and is about 2 miles above the mouth of Muddy Creek and 5 miles northeast of the town of Delta, in the southeastern corner of York County. Muddy Creek at this point has a drainage of 140 square miles and has a steep slope. It flows through a narrow rocky valley with steep wooded sides, the valley below the dam being entirely uncultivated.

The dam is a high timber-crib structure, perhaps the highest of its kind in the State, its greatest height being about 35 ft. Its crest length is only 130 ft. and it is founded entirely upon local schist rock. The dam backs water about 2 miles with an average width of pond of 200 ft., about 5 ft. of pondage being used.

There is no headrace or tailrace, but water is carried to the wheels through a steel penstock, 7 ft. in diameter and about 100 ft. long. The wheels are encased in a large steel drum, and two 3-ft. draft tubes conduct the discharge to the stream. There is one unit of two 24-in. runners, operating under 42 ft. head, each rated at 250 hp. These are direct connected to a 350-kw. generator, producing alternating current at 5,600 volts. A 6-kw. exciter is also belted to the wheel shaft. There is no auxiliary.

The transmission line extends to the large slate quarries in the vicinity of Delta. These constitute practically the entire market, although a small amount is supplied for lighting. The quarries operate only during the daytime, and their operation, together with the lighting load, requires continuous operation of the plant.

POTOMAC BASIN

The Potomac Basin includes portions of Franklin, Bedford, Fulton, Adams, Somerset and Cumberland counties. None of the streams are large and all flow in a general southerly direction, parallel to the ridges of the Alleghenies, being characterized by moderate slopes and absence of waterfalls. The topography is chiefly mountainous and consists mainly of alternating valleys and ridges. The region has had little industrial development, but agriculture flourishes, consequently flour and grist mills are fairly numerous, while there is only one hydroelectric plant and this is of 35 hp. capacity. With coal fields close to the western portion and railroad connections to the principal towns the prices for coal are moderate, and little opportunity for water power development exists.

UPPER ALLEGHENY SUB-BASIN

In the Upper Allegheny Sub-basin are included all of Warren and portions of McKean, Crawford, Venango, Erie, Forest, Potter, Mercer, Clarion, Butler, Elk and Armstrong counties. The district lies in the Allegheny Plateau west of the Allegheny Mountains and the topography is hilly. The region is sparsely settled, except where oil

and gas have caused industrial developments. These cheap fuels have discouraged water power developments, and consequently, there are few of importance and no hydroelectric plants. One large improvement, involving a storage reservoir, has been proposed for Tionesta Creek which flows into the Allegheny River on the east, 20 miles above Oil City, but this project is still in the promotion stage.

MIDDLE ALLEGHENY SUB-BASIN

The Middle Allegheny Sub-basin includes portions of Jefferson, Clarion, Elk, Armstrong, Indiana, Clearfield, Forest, McKean and Butler counties. This country is covered almost entirely by the watersheds of five streams, the Clarion River, Red Bank, Mahoning, Crooked and Cowanshannock creeks. The region is supplied with coal, gas and some oil, affording cheap fuel. Few water powers have been developed and there is only one hydroelectric plant, which is of 260 hp. capacity and is located on Red Bank Creek, at New Bethlehem. Charters, however, have been granted for very complete developments on the Clarion River, and Crooked and Cowanshannock creeks, while schemes have been proposed for utilizing the other streams of the basin. These streams are worthy of considerable study, as land is cheap, railroads are few and there are several possible storage sites.

LOWER ALLEGHENY SUB-BASIN

The watershed of the Kiskiminitas River constitutes nearly all of the Lower Allegheny Sub-basin, which includes portions of Westmoreland, Indiana, Somerset, Cambria, Allegheny, Armstrong and Butler counties, embracing a populous district supplied with cheap fuel from well developed coal fields. A few water powers have been developed, but only one hydroelectric plant and that of 100 hp. capacity is in operation. Projects involving storage reservoirs, for which there are some sites in the Kiskiminitas River Basin, have been proposed, but so far have not been thoroughly studied.

MONONGAHELA SUB-BASIN

The drainage area of the Monongahela Sub-basin lies mostly in West Virginia, and the part in Pennsylvania occupies Fayette County and portions of Greene, Washington, Allegheny, Westmoreland and Somerset. The Monongahela River has been improved for navigation up to Fairmont, West Virginia, and is now supplied with a number of low dams, possible sources of future water power. The Youghiogheny River, its principal tributary, flows northward from northwestern Maryland and has a heavy fall through a great portion of its course. This stream has the only hydroelectric plant in the basin, a small one of 60 hp., at Ohio Pyle.

Though the region is supplied with abundant coal and to some extent with gas, it has possiblities for power development. A large plant has been under construction on the Cheat River, a tributary of the Monongahela, in West Virginia, close to the State line. This plant has been intended to supply Pennsylvania markets in the Monongahela Basin, and other projects are proposed in the same locality, although the generating stations will not be in Pennsylvania.

MAIN OHIO SUB-BASIN

In the Main Ohio Sub-basin has been included that portion of the watershed of the Ohio River between the junction of the Monongahela and Allegheny rivers and the boundary of Pennsylvania. It covers portions of nearly all the western counties, embracing all of Beaver and Lawrence and portions of Mercer, Butler, Washington, Allegheny, Crawford, Greene and Venango counties. The largest tributary is the Beaver River, which drains practically all of the basin lying north of the Ohio. The sub-basin lies in the Allegheny Plateau and is rugged in topography, although free from pronounced mountain ranges. There are extensive deposits of coal in the southern portion and oil and gas are found within its limits, making fuel-produced power very cheap. There are, however, some small water powers and two hydroelectric plants, aggregating 1,900 hp. Several dams on the Beaver River having utilized water power for manufacturing purposes, are described in Appendix C, page 106.

PENNSYLVANIA POWER CO.—CONNOQUENESSING CREEK

This plant, at Ellwood City, Lawrence County, about 2 miles above the mouth, was originally built by the Ellwood Power Co., chartered October 19, 1900, but was subsequently bought by the present company, chartered December 7, 1904. It was destroyed by fire in 1908 but promptly rebuilt. The company is now controlled by the Republic Railway & Light Co. of New York, which also controls a large steam plant near Youngstown, Ohio, and the light and power distribution at New Castle, Sharon and Youngstown. The Ellwood City plant has recently been connected with this system.

Connoquenessing Creek is a large tributary of the Beaver River, into which it empties about 8 miles above the mouth. The creek has a drainage area of 840 square miles, of which only a small percentage is forested.

Development is secured by a dam and short headrace and tailrace The spillway is of the timber-crib type, about 175 ft. long and 30 ft. high, including 3-ft. flash-boards. At the north end is a short section of earthen embankment, while the power house substructure on the south end is a continuation of the dam. The backwater extends 1.75 miles, but the reservoir does not afford appreciable seasonal storage.

The brick power house has two vertical-shaft, direct connected units under an average head of 24 ft. The loss of head in the forebay and approaches is quite large, due to the deposit of material in flood stages and to the cramped design of the water channels. The turbines are 54 in., rated at 750 hp. each, and the AC generators are rated at 625 kw. To each unit is geared and belted a 26-kw. exciter and each is controlled by a governor. Wheels and gates are set in concrete flumes and the steel draft tubes are 6 ft. in diameter.

In the generator room are two 500-kw. steam turbines; also, for excitation purposes, a 36-hp. motor-generator set and a 12.5-kw. steam turbine, with a DC generator. The masonry work about the plant is of substantial character and protection against floating ice is secured by submerged openings in a heavy masonry wall at the forebay entrance.

The plant has supplied light and power to the municipality of Ellwood City, which has a distributing system and retails power. The company has also sold power at Zelienople and West Pittsburgh, each distant about 7 miles, to Wurtemburg, and to the Borough of Wampum.

BEAVER COUNTY LIGHT CO.—BEAVER RIVER

This plant was formerly owned by the Beaver Valley Electric Light & Power Co., recently absorbed by the Beaver County Light Co. It is on the west bank of the river just above the Borough of Fallston and on the canal of the Fallston Water Co. The plant is in one end

of the steam station which has steam turbines of 2,500 kw. capacity, while the water plant has two wheels rated together at 400 hp. under 9-ft. head. These, through ropes and a counter-shaft, drive two DC arc light machines of the constant current type, each of 120 kw. or 115 lamps capacity. When water power is not available, the arc machines are driven by a motor. The flood of March, 1913, filled up the forebay in front of the wheels, and at the time of inspection the plant had not resumed operation.

APPENDIX C

DIRECT USE OF WATER POWER FOR MECHANICAL PURPOSES

Census reports and other reliable sources of information show that the direct application of water power for manufacturing purposes has been steadily diminishing for a number of years, and that at this time the total is much less than that of hydroelectric operations.

In 1906 and 1907 the Water Supply Commission made an effort to secure a census of water power installations within the State. This census, while somewhat incomplete through the failure of some of those addressed to furnish the requisite data, was sufficient to afford considerable valuable information. The larger number of the developments reported were flour and feed mills, a smaller number were textile and paper mills, iron and steel manufactures and some other industries. These latter, while fewer in number, were generally larger in size and capacity than the former. A number of small hydroelectric plants were also reported.

Later inquiries have demonstrated that since the time of the above census, many of the operations then reported have either been permanently abandoned or are temporarily inactive, while many others have been converted into hydroelectric plants.

Probably the chief value of the canvass was to show the distribution of water power plants throughout the State. The operations reported are listed in Table No. 14, under the same territorial classification as that adopted for hydroelectric plants. This distribution corresponds in a general way with that of the latter as shown in Fig. 4, page 20, and exhibits a corresponding concentration in certain districts. More than one-half of the hydroelectric plants listed are found in the three divisions of the Delaware Basin and the Lower Main Susquehanna Sub-basin, while 49 per cent of all water powers classified are in the same districts. It is inferred that the same causes control the concentration in each case.

While the above statements tend to show a marked decrease in the number and capacities of plants making direct use of water power for manufacturing purposes, yet there seems to be no good reason why the future should not witness a reversal of this tendency. The success, which, in a number of instances, has attended the establishment of some of the lighter manufacturing industries at the sources of this power, offering also the advantages of cheaper sites as well

as lower-priced labor, due to the cheapened cost of living, is such as to prompt a more general study of the field. Many small manufactures now confined to the larger cities could no doubt be profitably operated in these rural localities, the improved transportation due to the extension of both steam and electric railways and the improvement of highways is an important element in the success of these enterprises, the lack of which, was one of the prime causes of the abandonment of many once-promising ventures.

TABLE No. 14. *Water Powers by Sub-basins*

Basin or Sub-basin.	Total water plants reported.	Hydroelectric plants.
Upper Delaware,	86	3
Middle Delaware,	102	4
Lower Delaware,	181	9
Upper North Branch Susquehanna,	48	3
Lower North Branch Susquehanna,	62	4
Upper West Branch Susquehanna,	24	0
Middle West Branch Susquehanna,	47	5
Lower West Branch Susquehanna,	44	1
Middle Main Susquehanna,	61	4
Upper Juniata,	73	2
Lower Juniata,	61	2
Lower Main Susquehanna,	249	27
Potomac,	62	1
Upper Allegheny,	52	0
Middle Allegheny,	26	1
Lower Allegheny,	16	1
Monongahela,	25	1
Main Ohio,	40	2
Erie,	4	0
Total,	1,263	70

As data upon the mechanical utilization of water power are not complete, the plants have not been described in detail. There are, however, certain areas of concentration containing typical developments worthy of attention, which are described below under three general sub-divisions, namely, the Delaware, the Susquehanna and the Ohio basins.

DELAWARE BASIN

DEXTER-LAMBERT CO.—WALLENPAUPACK CREEK

This company operates a large silk mill on the outskirts of the Borough of Hawley, Wayne County, utilizing a natural fall of about 60 ft. in a distance of less than 200 ft. Diversion is made by a timber-crib dam about 100 ft. long and 8 ft. maximum height, arching upstream with a 300-ft. radius.

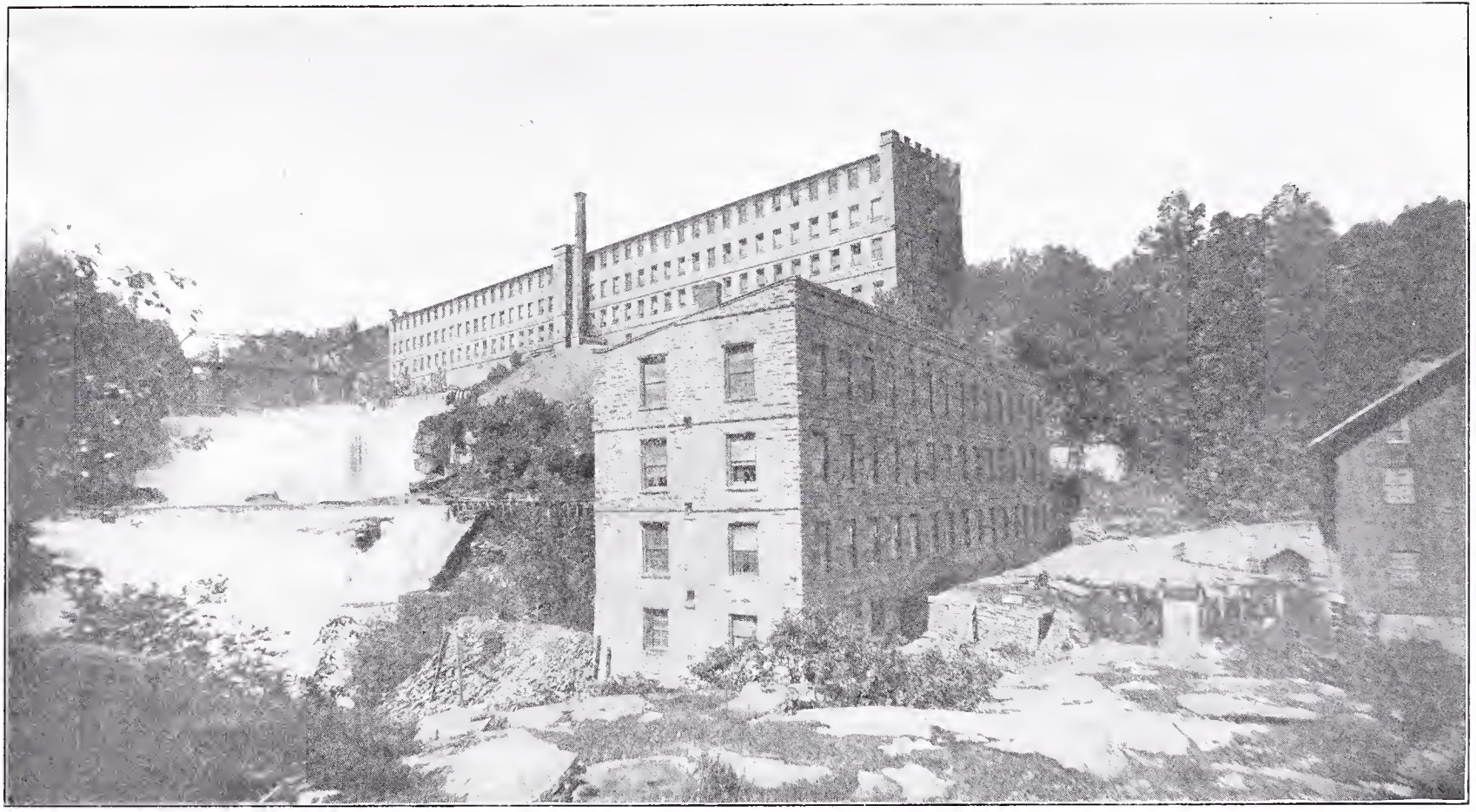


Fig. 22. Mills at Paupack Falls, Wallenpaupack Creek

From the pond, water flows through a timber flume about 150 ft. long to a vertical shaft excavated in the rock of the gorge. At the bottom of this shaft is a 450-hp., 40-in. turbine, on a vertical shaft and controlled by wicket gates and a governor. Water is carried from the wheel through a rock tunnel about 60 ft. long, to the pool of the Paupack Power Co. below. This wheel operates the mill machinery under a day load only.

The water supply is inadequate in the summer, as there is no pondage in the gorge, but a small wooden dam at the head of the falls at Wilsonville, one-half mile above, gives sufficient pondage to regulate the flow so as to carry the day load. This also aids the operation of the Paupack Electric Co. (see page 59) just above the silk mills and is conducted in co-operation with the latter company.

This power also drives a 25-kw. DC dynamo for lighting the mill during the winter time. The installation has been in service 35 years, during which time the turbine has been replaced twice.

ANALOMINK PAPER CO.—BRODHEADS CREEK

This is the second largest power on Brodheads Creek and is located one-half mile above the mouth, where there is a modern and substantial development peculiarly adapted to the needs of the plant.

The dam is a novel structure, about 17 ft. high from the bottom of the upstream cut-off wall, and is stated to be 128 ft. long between wing walls and 68 ft. wide overall. Most of this width is represented by a concrete apron below the overfall section, which, together with three cut-off walls, protects the bed of the creek. This dam has been in use 9 years and, although on a sand foundation, has given no trouble.

A headrace 600 ft. long conducts water to the wheels, which are mounted in pairs on horizontal shafts. Two pairs, 36 in. diameter, are rated at 250 hp. per unit; a third consists of two 32-in. special wheels rated at 150 hp., all under a head of 20 ft.

In the spring, when the discharge of the creek is heavy, the two large units are used for grinding pulp and it is found feasible to grind a year's supply in about 4 months. The small unit operates minor machinery about the plant and a steam engine of 150 hp. is provided for auxiliary service during low water. The paper machinery is driven by steam engines and electric power is purchased for auxiliary service.

WATER POWER ON CANAL OF LEHIGH COAL & NAVIGATION CO.

The Lehigh Coal & Navigation Co. was organized under special Act of Assembly, for the purpose of improving the navigation of the Lehigh River and of constructing and operating a canal adjacent to it. This company operated a system of slack-water navigation, ex-

tending from White Haven, Luzerne County, along the Lehigh and Delaware rivers to Bristol, Bucks County. In 1862, navigation was discontinued above Mauch Chunk and the dams were abandoned and have gradually been eliminated except one at White Haven and another above Mauch Chunk. Navigation, however, has continued below the latter place.

The system, utilizing the surplus water, offered many opportunities for power development at mills located between the canal and the river. Such installations were relieved of the large construction costs, but were subject to rental charges for the use of water.

The existing water power plants on the Lehigh Canal are summarized in three tables here presented.

Table No. 15 shows the physical characteristics of the several dams, all of which were on the Lehigh River, and were employed to form ponds and to divert water into the canal.

Where the canal follows the Delaware, it receives streams originally flowing into that river. It is also fed at New Hope by two diverting devices, one a controlled channel from the river and the other a mechanical lifting device described on page 97.

TABLE No. 15. *Dams of Lehigh Coal & Navigation Co.*

Location.	Length in feet.	Fall at dam in feet.
White Haven,	375	23
"Packer's" (above Mauch Chunk),	380	16
Mauch Chunk,	280	12
One-half mile below Parryville,	480	10
One mile below Lehigh Gap,	500	5
Treichler,	480	14
Laury,	450	10
Hokendauqua,	550	5
Allentown,	500	10
Glendon,	700	11
Easton,	340	16

Table No. 16 shows the rates imposed at this time by the canal company for the use of water. Leases are executed for 10-year periods upon the basis of the power demand determined by the canal company's engineers and subject to the condition that the latter company may retain all water necessary for navigation. These rents are based upon the price of coal at the site of the power used, assuming that the amount of coal to be required is not in excess of 2 pounds per hp.-hr. Such efficiency, it is claimed, would be attained by producer gas and gas engines employing anthracite. The schedule affirms the

principle that the value of water power is chiefly determined by the price of coal at the point of power utilization. Table No. 17 shows the number and character of installations and the extent to which the surplus water of the canal system has been utilized for power. It shows that there are 23 developments along this canal system, of which four are hydroelectric plants with an aggregate capacity of 2,970 hp. or 70 per cent of the total on the canal. The other 19 plants have 1,308 hp. and utilize the power for driving mill and factory machinery. In this district the same tendencies are observed which pertain to the State as a whole; these are, the utilization of power for mechanical purposes in small units and the devotion of the greater part of the available energy to the generation of electricity. An inspection of the tables shows also that much power is as yet unused on this canal system. The two large plants which constitute the greater part of the installation on the canal are below Bethlehem, although above this point there are a number of small powers. There is additional opportunity for the development of hydroelectric plants in this region and it is believed that the policy of the Lehigh Coal & Navigation Co. is favorable to the granting of further leases.

UNION MILLS PAPER CO.—DELAWARE RIVER

This company utilizes water power from the rapids on the Delaware River at New Hope, opposite Lambertville, New Jersey. A wing dam, of the timber-crib type, built jointly by the paper company and the Lehigh Coal & Navigation Co., deflects water into a forebay, from which both companies draw their supplies. The water taken by the former operates the turbines in its paper mill.

This power is developed under about 7 ft. head, using one 56-in. and two 78-in. turbines, with a total capacity of 450 hp. This average amount of water available will produce only about 325 hp., and some auxiliary steam machinery is necessary.

The water taken from the forebay by the canal company propels a curious feeding device which lifts water into a flume supplying the canal. This device comprises a large wooden, bottomless-bucket, undershot wheel, 20 ft. in diameter and 20 ft. in length, operating under about 3-ft. head; and a direct connected lifting unit. The latter is a wooden wheel of the "flash" type, 16 ft. in diameter and 20 ft. long, its buckets provided with bottoms and the blades inclined about 10 degrees to the radius. Water is raised from a passage connecting with the forebay, to a large flume 6 ft. by 16 ft., which passes underneath the paper mill to the canal. A rough estimate, made at the time of inspection, showed that about 60 second-feet of water were being delivered to the canal with an efficiency probably less than 15 per cent.

TABLE No. 16. *Minimum Rates to be Charged for Water Power on the Lehigh and Delaware Division Canals, Based on Comparison with Cost of Production of Power from No. 1 Buckwheat Coal at Corresponding Points*

Location of Plant.	Distance from Mauch Chunk in miles.	No. 1 Buckwheat Coal.		Water Power Service—12 hrs. per Day for 300 Days per Annum.				Water Power Service—20 hrs. per day for 300 Days per Annum.			
		Mode of delivery.	Price per gross ton.	Cost of coal per hp. per annum. $1\frac{3}{4}$ lbs. coal per hp. hr.	Water power rate per hp. per annum. For installation of 500 hp. and over.	Cost of coal per hp. per annum. 2 lbs. coal per hp. hr.	Water power rate per hp. per annum. For installation of less than 500 hp.	Cost of coal per hp. per annum. $1\frac{3}{4}$ lbs. coal per hp. hr.	Water power rate per hp. per annum. For installation of 500 hp. and over.	Cost of coal per hp. per annum. 2 lbs. coal per hp. hr.	Water power rate per hp. per annum. For installation of less than 500 hp.
White Haven,	18.0	R. R.	$2 00	$5 62	$8 00	$6 42	$9 00	$9 36	$10 75	$10 70	$12 00
Mauch Chunk,	0.0	Canal	1 65	4 64	6 75	5 30	7 50	7 72	9 00	8 83	10 00
Bowmans,	6.3	Canal	1 90	5 34	7 75	6 10	8 75	8 89	10 25	10 17	11 50
Walnutport,	13.0	Canal	2 00	5 62	8 00	6 42	9 00	9 36	10 75	10 70	12 00
Treichlers.	18.1	Canal	2 00	5 62	8 00	6 42	9 00	9 36	10 75	10 70	12 00
Laurys,	20.0	Canal	2 00	5 62	8 00	6 42	9 00	9 36	10 75	10 70	12 00
Siegfried,	22.4	Canal	2 00	5 62	8 00	6 42	9 00	9 36	10 75	10 70	12 00
Northampton,	23.6	Canal	2 00	5 62	8 00	6 42	9 00	9 36	10 75	10 70	12 00
Catasauqua.	25.6	Canal	2 00	5 62	8 00	6 42	9 00	9 36	10 75	10 70	12 00
Allentown,	28.0	Canal	2 05	5 76	8 25	6 58	9 25	9 59	11 00	10 97	12 25
East Allentown,	29.3	Canal	2 05	5 76	8 25	6 58	9 25	9 59	11 00	10 97	12 25
Bethlehem.	34.0	Canal	2 05	5 76	8 25	6 58	9 25	9 59	11 00	10 97	12 25
South Easton,	45.0	Canal	2 05	5 76	8 25	6 58	9 25	9 59	11 00	10 97	12 25
Raubsville,	51.8	Canal	2 25	6 32	8 75	7 22	10 00	10 53	11 75	12 04	13 25
Uhlertown,	65.0	Canal	2 35	6 60	9 25	7 54	10 50	11 00	12 25	12 57	13 75
Yardley,	91.2	Canal	2 35	6 60	9 25	7 54	10 50	11 00	12 25	12 57	13 75

TABLE No. 17. *Water Power Installations along Canal of Lehigh Coal & Navigation Co.*

Name.	Character of Plant.	Location.	Turbines, number and diameter.	Head in ft.	Capacity in hp.
White Haven Water Co., ...	Pumping Station,	White Haven, ...	1, ...	18.8	21
C. R. R. of N. J., ...	Pumping Station,	White Haven, ...	.....	.....	15
White Haven Silk Co., ...	Silk Mill, ...	White Haven, ...	1-28-in., ...	24.0	90
Wilson J. Hauser, ...	Electric Plant, ..	White Haven, ...	1-27-in., ...	26.0	150
Wilmot Engineering Co., ..	Machine Shop, ...	White Haven, ...	1-27-in., ...	14.9	30
Carbon Transit Co., ...	Electric R. R., ..	Mauch Chunk, ...	2-51-in., ...	11.0	320
J. S. McCormick Co., ...	Foundry Facing,..	Mauch Chunk, ...	1-21-in., ...	19.8	53
Prince Mfg. Co., ...	Paint Works, ...	Lock No. 15, ...	1-42-in., ...	.....	188 ?
			1-24-in., ...	15.0	60 ?
Prince Mfg. Co., ...	Paint Works, ...	Bowmanstown, ...	1-20-in., ...	14.2	84 ?
			1-18-in., ...		29 ?
Mauser Milling Co., ...	Flour Mill, ...	Treichler, ...	1-36-in., ...	15.4	107
Mauser Milling Co., ...	Flour Mill, ...	Laury, ...	1-42-in., ...	.....	70 ?
Lawrence Cement Co., ...	Pumping Station,	Siegfried, ...	5 ft. by 6 ft. wheel.	6.0	40
Mauser & Cressman, ...	Flour Mill, ...	Catasauqua, ...	1-45-in., ...	9.5	100
C. R. R. of N. J., ...	Pumping Water,..	Lock No. 39, ...	1-18-in., ...	10.5	7
C. R. R. of N. J., ...	Pumping Water,..	Lock No. 40, ...	1-23-in., ...	6.7	16
Estate Jacob Saeger, ...	Flour Mill, ...	Allentown, ...	1-35-in., ...	8.5	50
Pettinos Brothers, ...	Foundry Facing,..	Bethlehem, ...	1-33-in., ...	13.0	73
C. R. R. of N. J., ...	Pumping Station,	Bethlehem, ...	1-18-in., ...	14.7	10
Mineral Springs Ice Co., ...	Ice Plant, ...	Bethlehem, ...	1-30-in., ...	16.2	135
Easton Gas & Electric Co. (Penna. Utilities Co.), ...	Electric Plant, ..	Easton, ...	2-54-in., ...	18.0	1,400
Clymer Power Co., ...	Electric Plant, ..	Raubsville, ...	2-36-in., ...	32.0 and 16.0	1,100
Wm. H. Overpeck, ...	Flour Mill, ...	Uhlertown, ...	1-36-in., ...	.....	.....
			1-48-in., ...	10.0	40
Yardley Mills Co., ...	Flour Mill, ...	Yardley, ...	1-33 in., ...	12.0	90
			Total, ...	.....	4,278

TRENTON WATER POWER CO.—DELAWARE RIVER

This company bought in 1845 the property and rights of the Trenton & Delaware Falls Co., incorporated in 1831. The present company has passed through various controls, but still holds its rights and canal property.

Water is taken from the Delaware River by a diversion dam at Scudder's Falls, 6 miles above Trenton, and is carried by canal to the latter city, where it is sold to mills located on the river bank above the Pennsylvania R. R. bridge. These mills buy water based on the size of orifice; and the capacities of their wheels are listed in Table No. 18.

TABLE No. 18. *Mills Supplied by Trenton Water Power Co.*

Name.	Business.	Head ft.	Wheels, number and diameter.	Capacity hp.
Brookville Rubber Co.,	.....	.....	.....	Small
John Williams Mfg. Co.,	Woolen Mill,	12–13	1-56-in.,	40
Golding Sons Co.,	Flint Mill,	12–13	1-56-in.,	60 ?
Thompson & Co.,	Flour Mill,	14	2 small,	75
Fisher & Norris Foundry Co.,	Mfgrs. of anvils,	.....	Breast wheel,	50 ?
John E. Thropp & Sons Co.,	Foundry,	14	1-36-in.,	50 ?
			Total,	275

The Trenton Power Co. has recently been formed to develop power from the residual water. The calculated available power is about 1,200 hp. and the capacity of the proposed works will be about 1,000 hp. Electrical energy will be produced, but the details of the plant and disposition of the current are not known.

WATER POWERS ON THE SCHUYLKILL CANAL

The Schuylkill Navigation Co., incorporated September 2, 1815, under special Act of Assembly, constructed a series of canals, locks and dams for barge navigation of the Schuylkill River. It later passed under the control of the Philadelphia & Reading R. R. Co. and is now operated subject to the interests of this company. Although at one time the system of dams extended to Pottsville, the upper reach was abandoned many years ago and no dams exist above Port Clinton. Those still maintained are listed in Table No. 19.

TABLE No. 19. *Dams of Schuylkill Navigation Co.*

Number.	Location.	Length, ft.	Fall at dam, ft.	*Distance from Philadelphia, miles.
14	Lord's,	243	17.5	92.07
15	Hummel's (above Port Clinton),	265	15.0	90.32
16	Blue Mountain,	434	24.9	88.33
17	Kernsville,	476	4.8	87.61
18	Herbine's (Leesport),	242	8.5	76.15
19	Felix's (above Reading),	451	14.8	70.13
20	Leize's,	425	8.4	68.38
21	Shepp's,	317	8.7	67.23
22	Kissinger's (above Reading),	296	14.0	66.11
23	Little Reading (below Reading),	325	7.0	61.59
24	Big Reading,	423	18.8	59.12
25	Vincent (2 miles above Royersford),	342	6.5	36.17
26	Phoenixville (Black Rock),	376	8.4	28.31
27	Pawling (near Perkiomen Jct.),	329	4.3	23.28
28	Port Kennedy,	495	4.8	19.33
29	Norristown,	898	9.0	15.99
30	Conshohocken (Plymouth),	527	7.8	12.52
31	Manayunk (Flat Rock),	525	16.8	7.53
32	Fairmount,	1,200	†13.0	0.16

*At Callowhill Street Bridge.
†At low tide.

Although navigation is still maintained on the canal system, the development of water power is now of more importance than the original use of the canal. The power users obtain water under leases of various kinds and at different rates of compensation, dependent chiefly on the dates at which the contracts were made. Some rates are very low, but the present value of the power as indicated by more recent leases is from $10.00 to $15.00 per hp. per annum, according to the size of the installation and the anticipated load factor. This rate is on the same basis as that in force on the Lehigh Canal and is obviously controlled by the same principle. In Table No. 20, are listed the existing water power plants along the Schuylkill Canal, and the characteristics of each.

TABLE No. 20. *Existing Water Power Plants on the Schuylkill Canal*

Location.	Owner.	Character.	Head in ft.	Wheels, Number, Diameter and Type.	Capacity in hp.
Birdsboro,	Birdsboro Electric Co.,	Electric Light,	35.0	1-18-in.,	100
Cromby,	Phila. Suburban Gas & Electric Co.,	Electric Light and Power,	17.0	1-36-in. double runner, Smith-McCormick, 1-45-in. double runner, Smith-McCormick,	500
Phoenixville,	Phoenix Water Power Co.,	Electric Power,	11.0	3-69-in. Smith,	1,125
Bridgeport,	Jones and Wright,	Flour Mill,	.....	1-43-in. Risdon, 2-54-in. Risdon,	126
Norristown,	Norristown Borough (Samuel Kent),	Electric Light and Power,	10.0	2-56-in.,	25
Norristown,	F. G. Stitzinger,	Flour Mill,	8.0	1-33-in. Victor,	52
Conshohocken,	Henderson Supplee & Sons,	Flour Mill,	8.0	1-56-in. Leffel,	75
Conshohocken,	J. Wood & Sons Co.,	Plate Mill,	8.0	2-54-in. Eureka,	127
Manayunk,	William Spink,	Woolen Mill,	18.8	1-24-in. Hercules,	71
Manayunk,	Joseph Adams Co.,	Yarn Mill,	22.2	1-36-in. Risdon,	100
Manayunk,	Ripka Mills Co.,	Textile Mill,	23.0	2-40-in. Risdon, 1-30-in. McCormick,	420
Manayunk,	McDonald Paper Mills,	Paper Mill,	21.5	1-33-in. Smith,	300
Manayunk,	S. B. & B. W. Fleisher,	Yarn Mill,	23.0	1-39-in. McCormick,	310
Manayunk,	Philadelphia Hydro Electric Co.,	Electric Power,	23.0	4-33-in. double runner Smith,	2,800
Philadelphia,	City of Philadelphia,	Pumping,	12.0	1,	25
				Total,	6,617

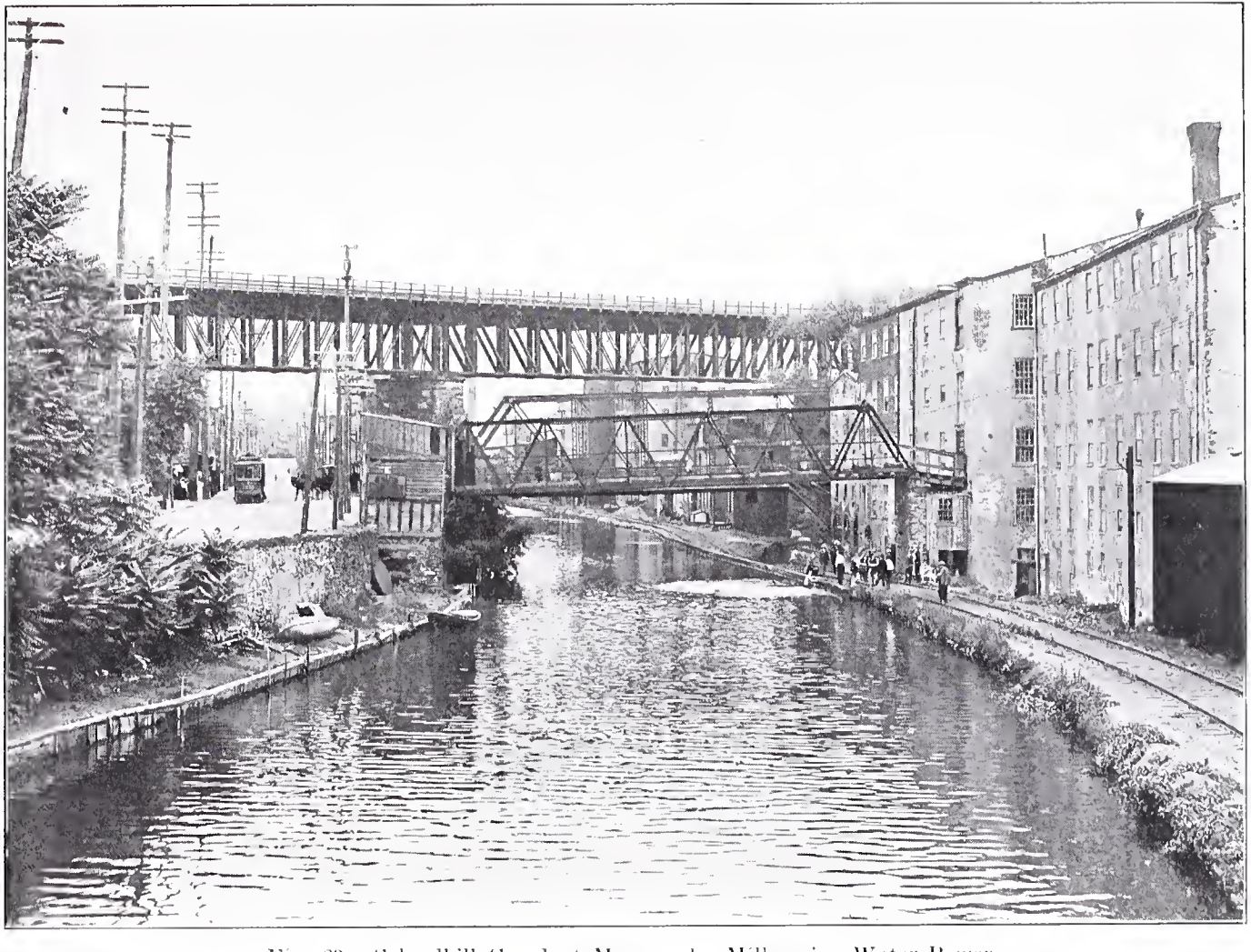


Fig. 23. Schuylkill Canal at Manayunk, Mills using Water Power

SCRANTON GAS & WATER CO.—ROARING BROOK

This company makes novel use of water power at its station at Nay Aug on Roaring Brook above Scranton, where four 8-in. and three 10-in. wells afford a part of the supply of the City of Scranton. Water is pumped from the wells by air-lift and the compressors are driven by water power or steam. Water power is obtained from the head in a large main of the Elmhurst reservoir. Between the reservoir and the plant there are about 15,000 ft. of 36-in. pipe and 9,400 ft. of 30-in. pipe, with 295 ft. gross head.

The 30-in. main is tapped for connection with two Pelton wheels operating air compressors. About 250 hp. is developed by one wheel and 200 hp. by the other. The tail-water is returned to Roaring Brook and is collected in No. 7 reservoir of the same company, about a mile below the pumping station.

The plant represents a utilization of the latent power in the mains of many water supply companies, and such use merits the attention of those interested in the administration of such systems.

E. I. DU PONT de NEMOURS & CO.—BIG WAPWALLOPEN CREEK

This company operated, although the works are now abandoned, a series of water powers on Big Wapwallopen Creek, which enters the North Branch of the Susquehanna River about 21 miles below Wilkes-Barre. The stream has a drainage area of 60 square miles and a fall of about 300 ft. in the lower 4 miles of its course. The developments of this company were in the lower 2 miles, in which the fall is about 200 ft.

The oldest of the developments, dating from 1859, was operated under 42 ft. head and included four turbines with a gross capacity of 262 hp. Water was available about 8 months in the year, but during the remainder a steam auxiliary was required. In recent years the turbines were used to generate electric current for distribution throughout the works.

The second development, made in 1868, obtained 72 ft. head and included five turbines aggregating 155 hp. This plant had an adequate water supply during 10 months of the year and utilized more than one-half its regular capacity during the remainder.

The third plant, built in 1869, had four wheels developing a total of 85 hp. under 17 ft. head. This power was developed during about 8 months and only a fraction thereof during the remaining four months.

All the developments were effected by low dams in the narrow gorge of the creek, diverting water through some sort of flume, and represented a total utilization of 131 ft. head. Although the mills have been abandoned, dissatisfaction with the water power conditions does not seem to have been the reason.

LYCOMING EDISON CO.—WEST BRANCH SUSQUEHANNA RIVER

This company operates, by water power, an auxiliary pumping station for its steam plant at the dam in the Susquehanna River at Williamsport. The plant is of small importance in itself, but is of interest as being the only known power development on the Lower West Branch proper. The dam is in the joint control of the Susquehanna Boom Co. and the Lycoming Edison Co., and was constructed in the interests of the lumber industry in northern Pennsylvania, the present use of power being purely incidental.

There are three 60-in. water wheels installed, each of 50 hp., under 9 ft. maximum head. One wheel, however, is sufficient for the load which consists of a centrifugal pump installed to lift 5,000 gallons per minute of condensing water to the steam-generating station. The Lycoming Edison Co., which is in the power business and has a large interest in the dam, is not making any effort to utilize the water power for the production of electric current, as their steam station is operated with high efficiency and is a satisfactory source of supply in itself.

MOUNT HOLLY SPRINGS PAPER MILLS—MOUNTAIN CREEK

Two paper mills, located at Mount Holly Springs, are now in the possession of Mr. S. F. Kitzmiller, Shippensburg, but are not in operation. The lower mill is a few hundred feet from the station of the Gettysburg & Harrisburg R. R. at Mount Holly Springs; the upper is about one mile upstream. Both mills are on Mountain Creek, tributary to Yellow Breeches Creek, which has a mountainous drainage of about 45 square miles.

The lower pond is formed by a timber-crib dam about 8 ft. high and 100 ft. long. From this dam a canal and timber flume, together 2,300 ft. long, lead to the mill which has two 30-in. turbines and one 18-in. turbine, the total rated capacity being 175 hp. under 18-ft. head.

The upper plant has a stone and earth dam about 8 ft. high by 450 ft. long, which floods about 10 acres. The headrace is 1,500 ft. and the tailrace 500 ft. long. The wheels are one 18-in. of 30 hp., one 30-in. of 60 hp. and one 33-in. of 60 hp., all under 15 ft. head. It is reported that one wheel can be used all the year and all three wheels about one-quarter of the year, a steam plant being used constantly.

MECHANICSBURG GAS & WATER CO.—YELLOW BREECHES CREEK

This company operates a pumping station by water power on the creek at a point about one mile southeast of Rossmoyne station of the Philadelphia & Reading R. R., and 6 miles above the mouth of the stream. The plant is in a mill formerly known as Miller's Mill, acquired by the water company about 1907, and since refitted. It is mentioned here as a typical utilization of power for pumping water for supply purposes. There are similar plants at Carlisle, New Cumberland, Media, and Bellefonte, as well as elsewhere.

The dam is a concrete structure of ogee section about 225 ft. long and from 6 ft. to 8 ft. high. Heavy concrete wing walls are provided and a concrete bulkhead extends from the head gates to the mill to protect the headrace and the settling reservoir of the purification system, from injury. The headrace and tailrace are behind this bulkhead and their banks are paved with stone to insure permanence.

About 7 ft. head is obtained and two 32-in. turbines develop 45 hp. each. These turbines are of the vertical-shaft type connected with a horizontal counter-shaft, which is belted to a triplex, direct-acting pump, rated at 750,000 gallons per day against 210 ft. head. There is also a reserve triplex pump of less capacity. This plant delivers filtered water to a reservoir near Mechanicsburg, from which it flows into the town mains.

YORK HAVEN PAPER CO.—SUSQUEHANNA RIVER

This company, incorporated about 1880, has large mills at York Haven, about 12 miles north of the city of York. The plant was built in 1884 for the manufacture of fibre paper. The water was conducted to the plant through a canal 70 ft. wide and about a mile long. A small diversion dam at the upper end of this canal deflected water from the river into the channel, about 14 ft. head being obtained.

With the construction of the plant of the York Haven Water & Power Co., 1900 to 1904, a different method of securing water was adopted. The paper company now draws water from the headrace of the power company, through six 9-ft. cast iron gates of the "Butterfly" type placed in the boundary wall, into the forebay of the paper plant. This forebay is about 400 ft. long by 100 ft. wide, with an average depth of about 8 ft.

About 19 ft. head is now obtained by the paper company, an aggregate wheel capacity of 2,450 hp. being installed. Two wheels are 700 hp., 72-in. diameter, the other three are also 72-in. wheels, but of only 350 hp. capacity. One of the larger wheels operates the "beater"

room, where the pulp is mixed preliminary to its passage to the paper machines. One of the smaller wheels is used to run some auxiliary machinery and another to operate a 75-kw. DC generator which supplies current for small motors throughout the plant. A 350-kw. AC generator is now being installed to be operated by the same turbine. The remaining wheels are connected to grinding machinery. All wheels are of the vertical-shaft type, hung on thrust bearings and geared to horizontal shafts by wooden and cast iron wheels.

Anchor ice has at times choked the wheels and shut down the plant. This trouble is said to be appreciably less since the construction of the existing headrace, as the anchor ice has more time to accumulate on the surface of the pond.

The manufacture of paper requires live steam for heating purposes and also the operation of paper machines at various speeds to which the steam engine is best adapted.

MILL OF P. A. & S. SMALL—CODORUS CREEK

This flour mill is on Codorus Creek about one mile below the city of York and interesting as having the largest known capacity of its type in the State. A diversion obtains about 8 ft. head and five 61-in. turbines are installed. These have a total capacity of 175 hp. and run at full capacity about 8 months of the average year, a steam auxiliary being required during the remainder.

Codorus Creek is also used by a number of other manufacturing plants, of which the largest are the Schmidt & Ault Paper Co. at York and the P. H. Glatfelter Co. at Spring Grove. Both operate paper mills and obtain about 100 hp., the former using about 6 ft. head and the latter 16 ft. These plants rely upon water power for auxiliary service only and have steam equipment of much greater capacity.

OHIO BASIN

POWER DEVELOPMENTS—LOWER BEAVER RIVER

The Beaver River is formed by the junction of the Shenango and Mahoning rivers at a point about three miles below New Castle, and has a total length of 21 miles, with a drainage area in northwestern Pennsylvania and northeastern Ohio of 3,030 square miles. Its principal tributary below the junction is Connoquenessing Creek. In the lower 5 miles the fall is about 50 ft. and four dams utilize the available head.

The lower or most southerly dam, about one-half mile above the mouth of the river, with a head of about 9 ft. has not been used in recent years. The former owners, M. T. & S. Kennedy, have sold their property and rights at this point to the Pennsylvania Railroad System, which is planning additional tracks on the east bank.

The second dam, between the boroughs of New Brighton and Fallston, gives about 14 ft. head. Another dam giving 16 ft. head is at Beaver Falls about one-half mile above the second and is under the control of the Beaver Falls Water Power Co. The fourth dam, at Eastvale, about a mile farther upstream, is controlled by the Beaver Valley Water Co. These dams and developments are discussed below.

NEW BRIGHTON-FALLSTON DAM

This dam is owned jointly by two corporations, the New Brighton Water Co. owning the eastern half, and the Fallston Water Co. the western portion. Both were incorporated by special Act of Assembly, the former on April 16, 1838, and the latter on April 8, 1848. Each is an association of power users who are entitled to use water from canals on either side of the stream in proportion to the number of shares held in the respective companies.

The dam, of the timber-crib type, was seriously damaged during the flood of March, 1913, when a large section was washed out near the center of the river. This gap was closed and the dam further improved by encasing the top and both sides with concrete, thus raising the crest about 2 ft. The headworks and gates of the eastern canal, which had also been washed out by the flood, were reconstructed in a substantial manner. The dam is now in good condition and the canal on the east bank seems safe and adequate.

The New Brighton Water Co. controlling the canal on the east bank, has 100 shares of stock, each share entitling the holder to the use of 7.5 inches width of forebay. These shares are held as follows:

Beaver Valley Water Co., ...	37 shares.
Pennsylvania R. R. interests, ...	63 shares.

The holdings of the railroad interests have been lately acquired by purchase of the shares of the Beaver Valley Electric Light & Power Co. (40 shares), Star Mills (12 shares) and R. B. McDaniel (11 shares). The Beaver Valley Water Co. is now the only user of the water in this canal. The railroad company has filled the race in front of the other mills and the Beaver Valley Light & Power Co's. plant, formerly of 400 hp., is dismantled.

The Beaver Valley Water Co. has two plants at this point, the principal one containing a 48-in., 200-hp. wheel, under 14 ft. head. It

operates a 12-in. by 24-in. duplex pump, rated at 1,500,000 gallons per day, which pumps filtered water into the mains against a pressure of about 150 lbs. per square inch. The station has also a 19-in., 40-hp. wheel, which operates a centrifugal pump of 4,000,000 gallons per day capacity, used to lift water from the river to settling basins preliminary to filtration; it is also provided with boilers and a high pressure steam pump of 3,000,000 gallons per day capacity and a steam engine which may be used to drive the centrifugal pump. Just above the last named station and on the same canal is another station of the same company, which is equipped with a 54-in., 250-hp. wheel operating under 12 ft. head and driving a 14-in. by 24-in. duplex pump of 2,500,000 gallons capacity, and a 19-in., 40-hp. wheel which drives another centrifugal pump of 1,500,000 gallons capacity.

On the west bank is the canal of the Fallston Water Co., also organized on a basis of 100 shares, distributed as follows:

C. C. & E. P. Townsend, ...	37 shares.
Beaver County Light Co., ...	44 shares.
M. T. & S. Kennedy Co., ...	19 shares.

The light company's plant has been closed since March, 1913, on account of choking of the forebay, and the mills of the Kennedy Co. were so badly damaged by the same flood that no effort has yet been made to restore them.

The rights of the Fallston Water Co. were obtained in 1804, when a grant was made by the General Assembly to David Townsend, an ancestor of the Townsends named above. This grant passed in 1820 to the Beaver Falls Water Co. and in 1848 to the Fallston Water Co., its successors, who constructed the present dam in 1866. This corporation's existence is only felt when it becomes necessary to levy assessments upon stockholders for the repair or enlargement of the works.

The Townsend plant has three wheels of 100 hp. each, under 12 ft. head and is the only user at the present time. The two mills of the Kennedy plant have one 48-in. and two 30-in. wheels, aggregating about 230 hp. capacity.

BEAVER FALLS WATER POWER CO.

This company owns a dam at Fifth Street, Beaver Falls, and a canal on the west bank of the river, there being no demand for power on the east bank. The timber-crib dam has an inclined upstream face and is about 700 ft. long. It suffered severe damage during the 1913 flood and was repaired with some difficulty. A gap which had been washed out was replaced with a timber-crib structure and a heavy concrete wall was placed on the downstream side of the crib. Several concrete buttresses were placed at intervals.

The 200 shares of the company are divided as follows:

Mayer China Co.,	10 shares.
Commercial Sash & Door Co.,	15 shares.
Beaver Falls Planing Mills Co.,	5 shares.
Union Drawn Steel Co.,	30 shares.
Standard Gauge Steel Co.,	35 shares.
William H. Hayes,	80 shares.
Scattering,	25 shares.
Total,	200 shares.

Of the above holders only four are users at this time. The Mayer China Co. has two 36-in. wheels, developing from 80 to 90 hp., under 12 ft. head. The Commercial Sash & Door Co. has two 30-in. wheels, said to be developing 175 hp., under 12 ft. head. The Beaver Falls Planing Mills Co. has one 24-in. wheel, developing 69 hp., at 13 ft. head. The Union Drawn Steel Co. is installing one 36-in. wheel, rated at 177 hp., under 15 ft. head. This company expects to realize 16 ft. average head and with a direct connected 100-kw. generator, will furnish current to motors in the plant. It is intended to duplicate the installation in the near future.

EASTVALE DAM—BEAVER VALLEY WATER CO.

The dam of the Beaver Valley Water Co. is a mile above Beaver Falls. It is a substantial timber-crib structure about 500 ft. long, curved upstream on a 1,250 ft. radius. It has a height of about 14 ft., a maximum width at base of 46.5 ft. and is built on solid rock. This is the only structure on the river which did not suffer material damage during the flood of March, 1913, only a few planks being ripped out of the sheeting.

The power is used for pumping purposes by the water company which has a large station on the east bank of the river. About 12 ft. head are obtained for three 48-in. turbines rated at 130 hp. each and one 54-in., rated at 150 hp. Three of the wheels drive 14-in. by 24-in. duplex pumps of 2,000,000 gallons capacity and the fourth, a 48-in. wheel drives a centrifugal pump rated at 6,000,000 gallons per day. A steam engine is provided for the alternative drive of the centrifugal pump and a large triple-expansion steam pump of 4,000,000 gallons capacity is also installed.

The proposed Pymatuning Reservoir, described in the 1913 Report of the Water Supply Commission, will improve water power conditions on the Beaver River.

Commonwealth of Pennsylvania

WATER SUPPLY COMMISSION OF PENNSYLVANIA

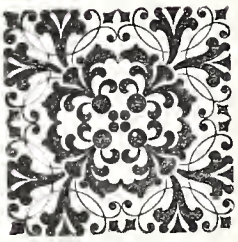
Water Resources Inventory Report

PART VIII

FLOODS

ACT OF JULY 25, 1913

HARRISBURG, PA.
WM. STANLEY RAY, STATE PRINTER
1916



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(Died May 14, 1915)

Vice Chairman

**BENJAMIN K. FOCHT, Lewisburg, Union County
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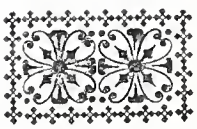

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LETTER OF TRANSMITTAL

Office of the Water Supply Commission,

Harrisburg, September 20, 1916.

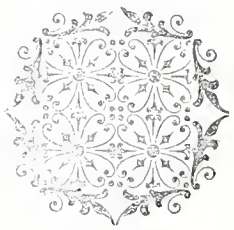
His Excellency, the Governor of the Commonwealth of Pennsylvania:

The Members of the Senate and the House of Representatives of the Commonwealth of Pennsylvania:

Gentlemen: The Water Supply Commission of Pennsylvania respectfully submits herewith Part VIII of the Water Resources Inventory Report, entitled "Floods," which contains a historic review of floods; discussions of their causes and the factors which aggravate their destructiveness; methods of flood control and amelioration of flood damage; conclusions and recommendations; tables showing the frequency and magnitude of floods on the large rivers of the Commonwealth and statistics of recent flood damage.

THE WATER SUPPLY COMMISSION OF PENNSYLVANIA,

THOMAS J. LYNCH,
Secretary.



PART VIII

FLOODS

(The data herein contained were collected during the year 1914, and the conditions described were those then existing.)

INTRODUCTION

Increasing damage by floods in Pennsylvania has led to a widespread but erroneous belief that destructive floods are increasing in frequency and intensity. Realizing that the truth concerning them cannot be known except by careful analysis of ample data, the Commission believes that it has secured sufficient facts concerning floods on the principal streams of the Commonwealth to make the data of practical value in determining methods of flood control. The object has been to ascertain the frequency of floods of different magnitudes and to determine the character and extent of recent damage, including analysis of the factors which aggravate their destructiveness.

HISTORIC REVIEW OF FLOODS

Great floods are recorded in the earliest accounts of settlement in Pennsylvania. Before the advent of the whites the Indians had gathered knowledge concerning the behavior of the streams along which they lived, and there was a tradition among them that "great floods" occurred on the Susquehanna and Delaware rivers at regular intervals of 14 years. Occasional reference is found in early writings to the warnings given by Indians to white settlers concerning the height of extreme floods, which were too often unheeded. The beginning of the history of destruction by floods is coincident with the first settlement by white men along the banks of streams, and one is therefore able to trace the history of floods to an earlier date in those locations where settlement first took place. The region around Philadelphia, the Wyoming Valley in the vicinity of Wilkes-Barre, and the Pittsburgh district stand prominent in this respect.

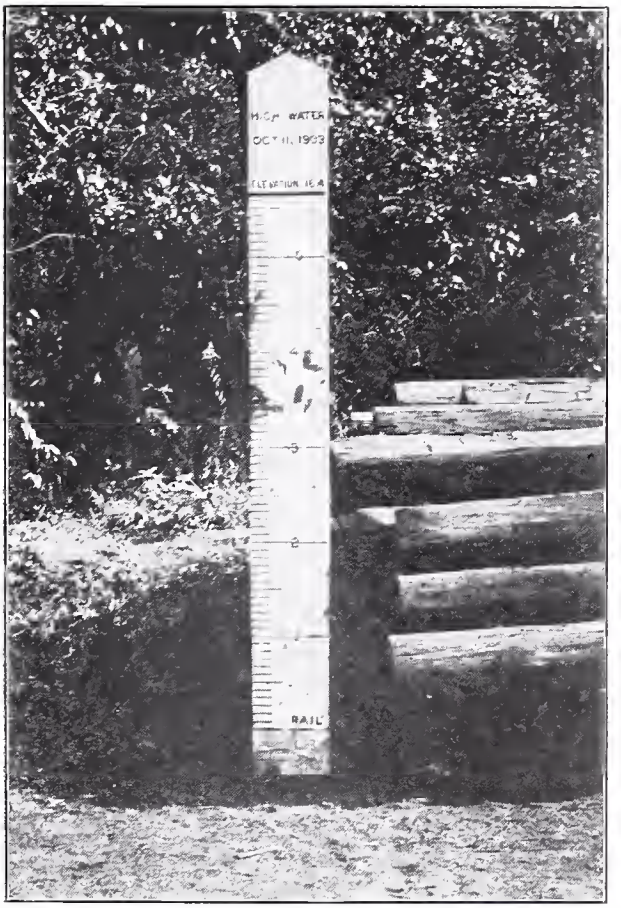
It is seldom possible to ascertain the height of early floods with any degree of accuracy, for data of this kind are necessarily approximate, and too much importance should not be attached to them. Channels, banks, bridges and encroachments are undergoing constant changes, and a given gage height today does not necessarily represent the same discharge that it did years ago. Nevertheless, by assigning proper weight to the recorded data, reasonably safe conclusions may be drawn regarding the periodic occurrence of floods.

There is no factor in the measurement and study of floods that is of greater importance than determining maximum or crest stages, for the extent of damage is almost entirely governed thereby. Also, except where it is the result of backwater from an ice dam or at the confluence of streams, the crest stage affords the only reliable index to the amount of water flowing. Special efforts have been made to distinguish clearly between the maximum or crest stage, and other gage heights not necessarily representing crest stages. River stage records do not, as a rule, give more than one, or at the most two gage readings in 24 hours, usually taken at fixed times of day. Of recent years instructions have been issued by both Federal and State authorities requiring observers to take special readings at time of high water, for the purpose of ascertaining the rate of rise and the maximum height attained; and this will explain why the later records furnish more complete data than the older ones. Next in importance to crest height is the corresponding discharge, which is valuable in determining the capacity of water courses and reservoirs, and in establishing relations between rainfall and run-off. Discharge figures published in this report have been largely derived from the records of the Water Supply Commission, and in part from those of the United States Geological Survey.

The earliest recorded floods occurred on the Delaware River in 1687 and 1692, and are mentioned in a letter written by Phineas Pemberton, dated February 27, 1692.* The 1692 flood is described by him as having risen 12 feet above the usual high water mark at the Delaware Falls (Trenton, N. J.), the water reaching the upper stories of houses on the lowlands. A detailed account of this flood appears in "History of the City of Trenton," by John O. Raum, Trenton, N. J., 1871, page 39, which also mentions the danger of inundation as foreseen by the Indians.

The greatest recorded flood on the Delaware River was that of October 10-11, 1903, which reached elevation 192.5 at Easton and 24.5 feet on the gage at Lambertville, N. J., corresponding to a discharge of 31.6 second-feet per square mile from a drainage area of 6,860 square miles. Other great floods which exceeded 20 feet on the Lambertville gage occurred January 8, 1841, June 8, 1862, and

*"Historic Tales of Olden Times Concerning the Early Settlement and Progress of Philadelphia and Pennsylvania," by John F. Watson, published Philadelphia, 1833, p. 262.



High Water Mark, Delaware River Flood of October 11, 1903, near Fieldsboro, N. J

March 2, 1902, the discharges amounting to about 25 second-feet per square mile. On the Lehigh River the greatest flood on record took place on February 28, 1902, reaching a stage of 25.9 feet on the gage at Bethlehem, equivalent to a discharge of 69.8 second-feet per square mile from a drainage area of 1,240 square miles. On the Schuylkill River the greatest recorded flood occurred September 2, 1850, with a 23.2 foot stage at Reading. The ice flood of March 15, 1784, on the Susquehanna River and the great "Pumpkin Flood" of October 5, 1786, on the same stream, which devastated the Wyoming Valley at a time when it was passing through the most trying period of its early history, are the first floods on the Susquehanna River of which reliable descriptions have been found.

In the Susquehanna Basin the flood of June 1-2, 1889, broke all records, reaching 32.4 feet at Williamsport on the West Branch and 26.8 feet at Harrisburg on the main Susquehanna corresponding to discharges of 61.7 and 29.3 second-feet per square mile from drainage areas of 5,670 and 24,100 square miles respectively. The Juniata River reached its maximum recorded stage of 35.9 feet at Newport, with a discharge of 53.8 second-feet per square mile from a drainage area of 3,380 square miles. The next highest flood in the Susquehanna Basin occurred on May 21-22, 1894, and was also principally caused by the western tributaries. The stage at Williamsport was 30.0 feet, representing a discharge of 51.9 second-feet per square mile, while at Harrisburg the stage was 25.4 feet, being equivalent to a discharge of 26.5 second-feet per square mile. The greatest flood on the North Branch was that of March 18, 1865, the stage at Wilkes-Barre being 33.1 feet, with a discharge of 25.0 second-feet per square mile from a drainage area of 9,920 square miles. This flood caused a 24.6 foot stage at Harrisburg, equivalent to a discharge of 25.0 second-feet per square mile. Other floods of 30 feet and over at Wilkes-Barre occurred on March 15, 1784, April 1807, March 2, 1902, and March 9, 1904, those of the first and last mentioned dates having been caused by ice jams. The other two gave discharges of 20 and 22.3 second-feet per square mile respectively. In the Ohio River Basin the history of floods begins in 1756 with the occupancy of Fort Duquesne by the French, frequent mention of trouble from floods appearing in the letters which emanated from this fort, and later from Fort Pitt.

The flood record for the Ohio River at Pittsburgh, covering 159 years, contains 185 floods with stages of 18 feet and above, 156 of which occurred during the 60 years covered by daily river stage observations. The highest recorded is that of March 9, 1763, which reached a stage of approximately 38 feet, corresponding to a discharge of 25 second-feet per square mile from a drainage area of 19,000 square miles. Next in height are the floods of January 9, 1762, and March 15, 1907, with stages of 36 feet and 35.5 feet respectively.

Other great floods are those of 1784 and 1832, which reached 35 foot stages, and those of 1787, 1806, 1810, 1816, 1852, 1884, and 1902, which reached 32 to 34 foot stages and discharged approximately 20 second-feet per square mile. The highest recorded flood on the Monongahela River occurred on July 11, 1888, with a gage height of 42.0 feet at Lock No. 4, corresponding to a discharge of approximately 38.5 second-feet per square mile, from a drainage area of 5,370 square miles.

Other great floods occurred on March 6, 1824, July 25, 1846, April 6, 1852, and July 25, 1896, discharging about 33 second-feet per square mile. The 37.4 foot stage on March 14, 1907, was traceable to backwater from the Youghiogheny River, which on that date experienced its maximum flood, the gage height at Connellsville being 18.4 feet, equivalent to a discharge of 41.2 second-feet per square mile from a drainage area of 1,320 sqnare miles. The Kiskiminitas River had its record flood on March 14, 1907, with a gage height of 33.8 feet at Avonmore, and a discharge of 53.8 second-feet per square mile from a drainage area of 1,720 square miles. On the Allegheny River the floods of April 10, 1806, and March 26, 1913, both of which reached a 30 foot stage at Kittanning, are the highest on record, and discharged at the rate of about 29 second-feet per square mile from a drainage area of 9,010 square miles. Other floods about one foot lower occurred on November 10, 1810, February 9, 1832, April 19, 1852, March 18, 1865, February 5, 1883, and March 20, 1905. On the Shenango and Beaver rivers the flood of March 26-27, 1913, broke all records, reaching 17.4 feet on the gage at Beaver Falls. The maximum discharge of the Shenango River at Sharon was 41.9 second-feet per square mile from a drainage area of 611 square miles.

Settlement in Pennsylvania began along the banks of the streams, which were the natural avenues of commerce and travel, and with few exceptions the towns of today are on the sites of the first settlements, having grown in disregard of the periodic visitations by floods. As these communities grew the extent of their suffering at time of flood became more and more accentuated, and their liability to flood damage has proved in some instances an impediment to progress.

A perusal of the harrowing accounts of flood devastation in Pennsylvania during the early half of the nineteenth century cannot fail to impress one with the then existing belief that destructive floods belonged to that category of exceptional events which, like earthquakes and other great calamities, frequently termed Acts of Providence, were of a nature against which man was powerless to provide and the recurrence of which was considered not only problematical but highly unlikely. Instead of profiting by such unfortunate experiences, mankind accepted them as inevitable evils and usually restored things to as nearly as possible the same condition that existed before the visitation.

Shenango River Flood of March 26, 1913, at Chestnut Street Bridge, Sharon. Water within One Foot of Flood Crest

The foregoing statements show that on most of the main streams great floods, excluding those caused by ice jams, are on the whole, commoner events than is popularly believed, and that most of the great floods have occurred in summer or fall and not during the spring. It also shows that nearly all rivers of Pennsylvania have had at least one flood of extraordinary proportions exceeding by far all other great floods. Notable exceptions are the Allegheny River and the North Branch Susquehanna River, the great floods on which differ but little in height.

CAUSES OF FLOODS

Floods are usually caused by combinations of concomitant factors. Complex as these combinations may be, it is possible to distinguish between primary causes, which are of meteorological origin, and contributory agencies, fixed or fortuitous, which intensify the effects produced by the former. Changed run-off conditions, caused by deforestation, extensive cultivation, municipal improvements, channel obstructions and other works, are responsible for noticeable changes in flood characteristics in some districts, but these are purely local and do not sensibly affect the behavior of the principal rivers.

Primary Causes

The three different types of floods on Pennsylvania streams produced by primary causes are:

1. Prolonged moderate rains, covering large areas and occurring principally in winter and early spring, when the soil contains a high percentage of moisture or is covered with snow; when plant growth and forests are least efficient in absorbing and retarding run-off, and evaporation is lowest. Such storms are responsible for the commonest type of freshets to which the main streams and principal tributaries are subject, the run-off from the drainage areas frequently exceeding the precipitation which initially causes the freshets. Small streams, as a rule, do not reach extraordinary stages and seldom overflow their banks. Typical examples of winter and spring floods are those of March 18, 1865, on the Susquehanna River, December 16, 1901, on the Delaware River and February 6, 1884, on the Ohio River and tributaries. When following severe cold spells storms of this kind are usually responsible for ice floods, which are characterized by the alternate breaking-up and lodging of the ice and the formation of ice dams which may raise the water level to a

great height. Such floods are probably the most destructive type and constitute a baffling feature in flood control problems. The high stages which accompany ice freshets are local and intermittent and are due to the ice dams, while the river flow seldom reaches unusual proportions. Temperature changes, and not precipitation, are the principal factors, but subsequent fluctuations in temperature may extend the duration and aggravate the proportions of ice floods, as was notably the case during the extraordinary ice flood on the Susquehanna River in 1875 which lasted three weeks.

2. Heavy and prolonged summer and fall rains over large areas are responsible for the second type of floods, which affects large and small streams alike. The rainfall may be continuous for several days and average 10 inches over a drainage basin. Excessive rates of precipitation and run-off are the main causes, and overbalance the factors which tend to decrease or retard the run-off. The highly absorptive condition of the soil, the retarding influences of the forests and other vegetation which are then at highest efficiency, the high rate of evaporation, and the low condition of streams avail little at such times. An inspection of the records published in Tables Nos. 1 to 17 reveals that almost invariably the greatest floods on record are of this class. Typical summer and fall floods occurred on October 10, 1903, on the Delaware River; June 1, 1889, on the Susquehanna River, and July 11, 1888, on the Monongahela River.

3. Torrential rains of great intensity, short duration and usually covering small areas are frequent occurrences during the summer, and, being commonly known as "cloudbursts," are characterized by extreme rates of run-off. Rates of rainfall of 1 inch in from 5 to 15 minutes have been repeatedly recorded. On August 3, 1898, there was a rainfall of 5.43 inches over about one-fifth of Philadelphia County in 1 hour and 44 minutes. Preceding the historic flood of June 5, 1892, on Oil Creek, over 10 inches of rain fell in 24 hours at Spartansburg. So sporadic is the occurrence of such storms and so localized is the havoc wrought that there is a paucity of recorded facts and data concerning them. They are responsible for the greatest floods to which the smaller streams are subject, and have furnished the highest known rates of run-off per square mile of drainage area in Pennsylvania. The highest recorded occurred on Bulls Run, a small tributary of the Susquehanna River, on July 15, 1914, which discharged at the rate of about 5,000 second-feet per square mile from a drainage area a little over one-half square mile. While the main rivers, as a rule, are little affected, there are instances on record where the simultaneous occurrence of a number of torrential rains in different parts of one drainage basin raised the main stream to flood stage. In spite of the short duration of the rain, floods of this type are singularly destructive, the damage to crops, highways, rail-

Roaring Brook Flood of July 10, 1914, at South Washington Street Bridge, Scranton

road embankments, bridges and culverts being particularly severe. Floods of this type occurred on July 10, 1914, on Roaring Brook, in Lackawanna County; July 24, 1912, on Dunbar Creek, in Fayette County; and July 26, 1874, on Spring Garden Run, in the city of Pittsburgh (Allegheny).

Contributory Agencies

Agencies not primarily responsible for high rates of yield or high local stages may be subdivided into those of fixed character peculiar to streams or the territory which they drain, and those of fortuitous origin. Those of fixed character are:

1. Compact or fan-shaped drainage areas which may cause the arrival of flood crests on tributaries to reach the parent stream when it is at flood stage. Streams draining such basins are subject to sudden and frequent high water of short duration.
2. Streams flowing in the same directions as those commonly traversed by storm centers are particularly subject to great floods.
3. Steep slopes and rocky ground with thin soil cover promoting rapid run-off.
4. Drainage areas lacking natural or artificial storage as lakes, swamps and reservoirs.
5. River channels which present conditions favorable to the formation of ice dams, causing inundations by backwater.
6. Backwater conditions above the confluence of streams during flood stages.
7. Forest covered plateaus at high altitudes which prevent deep snow from melting until late in the spring, when rainfall or high temperature, singly or in combination, may cause its sudden run-off.

The principal agencies of fortuitous origin are:

1. Prolonged rains with melting of deep snows.
2. Moderate rains, accompanied by high temperatures, over drainage areas upon which large amounts of snow have accumulated.
3. Frozen ground or saturated soil.
4. Extensive lumbering and forest fires which destroy the forest litter, a factor in retarding run-off, and may under certain conditions result in excessive erosion of hillsides causing soil to be deposited in the streams.
5. Natural or artificial restrictions which may cause stream channels to become inadequate for flood discharge. Deposits of culm or other trades waste and encroachments placed by man are among the most prolific sources of trouble of this kind.
6. The partial or complete failure of dams.
7. Accumulations of debris which may produce inundations over limited areas.

PERIODICITY OF FLOODS

There appears to be no justification for the popular belief that great floods are increasing either in number or intensity. The tendencies exhibited by different rivers vary greatly, and there is no well-defined or constant tendency common to all or shared even by streams that are closely related. There is but one steady trait in the character of floods in Pennsylvania, and that is their uniform variability. No satisfactory laws or cycles have yet been discovered which govern the occurrence of great storms, and it would be strange indeed if any regularity could be discovered in the height and occurrence of floods which primarily are the direct result of such storms.

The bare statement that a flood reached a certain height and inflicted a certain amount of damage, while of interest, is of little practical value unless it is known how often floods of similar height have occurred. It is evident that no sane conclusion can be reached with regard to the permissible cost of remedial measures until flood periodicity or frequency has previously been determined.

The periods intervening between extraordinary floods have varied on most of our streams from 40 to 70 years. Such periods represent much in the march of civilization or in the course of a human life. Many a small settlement has grown to be a large city and railroad systems have been built and brought into operation within such periods, little realizing the nature of impending trouble from this cause. Time bedims the recollection of great catastrophes which accounts for much construction in later years within flood zones. Few individuals or corporations would be governed in the selection of a building site along a stream by the happenings which took place 40 or more years ago, information concerning which is based on hearsay. Flood damage is annually becoming larger, due to more intensive occupation of the valleys, and misleads many into the belief that great floods are growing in height as well as in frequency.

Chronologically arranged tables of high water occurrences are the most useful form for studying the periodicity of floods, and are much to be preferred to any deductive reasoning based on theoretical considerations. Tabulations of this kind for 17 different localities are presented in Tables Nos. 1 to 17 inclusive. Additional tables are being compiled for other localities but are not sufficiently complete to warrant publishing.

A significant lesson to be drawn from the flood tables is that high water records covering about 100 years, and preferably longer, are

needed in order to deduce safe conclusions regarding the periodical occurrence of floods. Records covering from 50 to 60 years or less seldom contain more than one extraordinary flood, and a purely transitory tendency, exhibited during such a period, may be construed as an index of a general tendency, and so lead to erroneous conclusions. Many fallacious opinions regarding flood frequency are traceable to the use of too short records.

To appreciate the frequency with which destructive floods occur one must study long term records of stream flow. Systematic daily observations of river stages are the most valuable for this purpose, and when not obtainable, data must be gathered from various sources. The latter process, while not always satisfactory, often results in bringing together the dates of occurrence and establishes the frequency of the most serious floods.

Stream Gaging

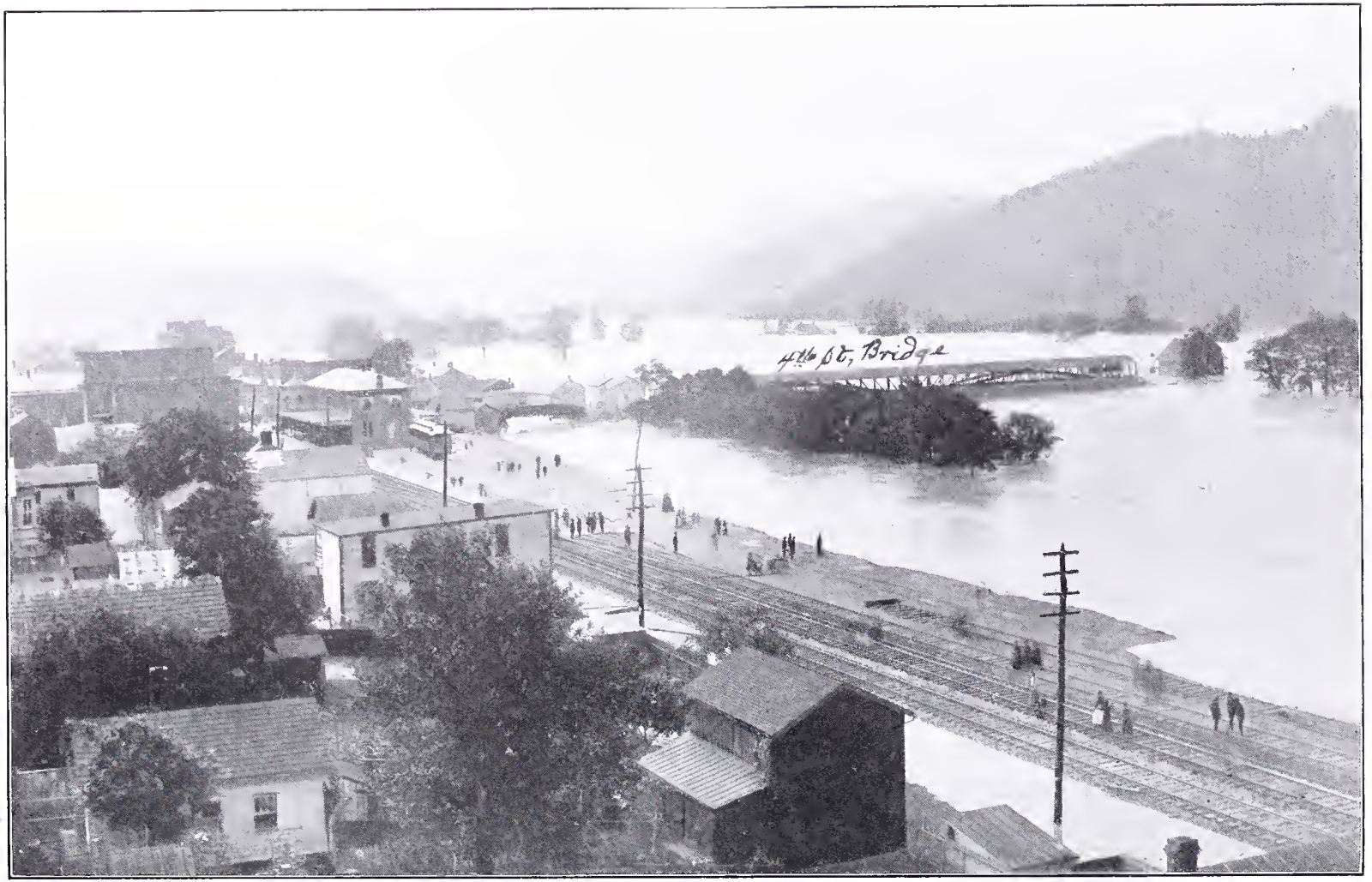
Stream flow records furnish the most valuable data for studying floods, and are also useful in many other important investigations relative to the utilization of streams. The Water Supply Commission maintains 95 gaging stations, 84 of which have been established since 1907, when it took over the stream gaging system in Pennsylvania started by the United States Geological Survey in 1897. In addition it receives records from 12 stations located outside of the State which are on streams tributary to Pennsylvania drainage basins. The United States Weather Bureau maintains a number of gages, for the purpose of securing data to forecast floods, a few of which were established in 1873 by the Signal Corps of the United States Army.

It is essential that the system of stream gaging be extended to cover all streams of importance, and that records already started be continued uninterruptedly, inasmuch as their value depends upon continuity as well as length of period covered. Had stream gaging records been started many years ago, the status of floods in Pennsylvania would have been better understood.

Flood Possibilities

That floods exceeding in magnitude any hitherto recorded are possible, will appear from the following considerations. The crest stage is usually caused by the simultaneous arrival into the main stream of the flood flows from a number of tributaries. As this crest travels down the main river it may be augmented by tributaries which are also high, and thus assume large proportions. The more nearly synchronous this action is on the part of the different tributaries the

higher the crest and the shorter its duration. Conversely, in the absence of such synchronism, floods may be devoid of distinct crests and te flow may extend over long periods at a nearly stationary stage. Analysis of a number of floods shows that rarely are many important tributaries instrumental in bringing about a high stage on the main stream. Uneven distribution of rainfall over the drainage basin as regards both time and amount usually causes decided differences in the behavior of the tributaries, and may serve to belate the flood flow on some and render others inconsequential. The storm of May 31, 1889, which produced the greatest flood on record on the Susquehanna River, reaching nearly a 27 foot stage at Harrisburg, affected principally the West Branch and the Juniata River; while the moderate precipitation which fell in the area tributary to the North Branch caused the latter stream to attain no unusual stage. Had this storm been distributed with uniform intensity over the entire Susquehanna Basin, a higher stage would have resulted on the lower river. A computation was made by the Commission to ascertain what the effect on the discharge of the Susquehanna River would have been had the Ohio storm of March 23-27, 1913, been spread as effectively as possible over the watershed. The resulting maximum stage at Harrisburg would have been about 31 feet, equivalent to a discharge of over 900,000 second-feet, or 37.5 second-feet per square mile of drainage area, an increase of more than 28 per cent over that of the 1889 flood. When it is considered that the precipitation which caused the latter flood exceeded any recorded rainfall over an area of similar extent in Pennsylvania, it will become clear that neither the Ohio nor the Delaware basins have as yet experienced anything like a possible maximum flood. On the Ohio River the flood of March 15, 1907, reached a stage of 35.5 feet at Pittsburgh, being the greatest flood on record since 1763. Little is known regarding the flood of that year, but full information is available concerning that of 1907. Maximum run-off occurred at that time on the Kiskiminitas and Youghiogheny rivers only; the Monongahela, though high, did not reach its previous record stage, and the Upper Allegheny contributed but little. The run-off from the combined drainage basins amounted to 22.8 second-feet per square mile, which is in striking contrast with the 29.3 second-feet per square mile for the Susquehanna River at Harrisburg in 1889. The difference becomes more striking when account is taken of the size of the respective areas drained: the Susquehanna above Harrisburg draining 24,100 square miles, and the Ohio at Pittsburgh 19,000 square miles. Normally the greater intensity of run-off should be expected from the lesser area. What a 37.5 or even a 29.3 second-foot per square mile flood on the Ohio River would entail in damage and loss of life in the Pittsburgh district cannot be foretold; but the probability of occurrence of such an event is extremely small. We know



Frankstown Branch Juniata River Flood of June 1, 1889, at Huntingdon

that such a thing has not taken place in the Ohio Basin during the 160 years since the establishment of Fort Duquesne; while on the Susquehanna the nearest approach to it occurred in 1889. However improbable the occurrence of such an event may be, it is none the less within the range of physical possibility, and we cannot say that the greatest floods now on record will not some time be exceeded.

ECONOMIC IMPORTANCE OF FLOODS

River systems at time of flood perform an important function in the economics of nature, for they not only relieve the land of surplus water but they are the only channels through which eroded materials are carried to the ocean or deposited on the flood plains. Wind and rain slowly but persistently carve and sculpture the earth's surface and deposit the resulting debris on the valley bottoms. At ordinary stages small streams are powerless to transport this ever accumulating debris; they are dependent upon the carrying power of their flood flows to sweep it into the main rivers. The latter in turn must await the action of freshets to clear their channels. The finer debris is borne in suspension, while the coarser particles are swept along the stream bed, and in addition to this mineral matter enormous quantities of organic wastes are transported. A large river and its tributaries may be likened to the sewer system of a city: as the flush tanks in a sewer system cleanse the sewers by periodically liberating large volumes of water to remove the solids which would eventually choke the sewers, so do storms create floods which fulfill the same important task for the streams.

Whatever may be undertaken to effect flood control or stream regulation, due cognizance must be taken of the equilibrium which exists in nature between the erosive powers of meteorological agencies and the transporting power of streams. To heedlessly upset this equilibrium would entail serious consequences, but much can be done to ameliorate flood conditions without disturbing it. Judicious improvement of river channels will materially reduce flood heights, yet conserve the scouring action which is so indispensable for their maintenance. Likewise reservoirs may be built to reduce the intensity of floods without impairing their transporting power. It is not within the power of man to modify the erosive action of wind and rain, but he can prevent at least part of the eroded materials from reaching the streams, and it is entirely within his power to prevent the deposition therein of trades waste and raw sewage.

FLOOD DAMAGE

The determination of actual flood damage is difficult, as much of it cannot be monetarily expressed. This is especially true of the intangible and indirect losses caused by stagnation of business and social activities, by depreciation of real estate values, shutting down of manufacturing plants and paralyzing of public utilities, the demoralizing effects of which are usually far-reaching and may continue to make themselves felt for long periods of time. Inconvenience, privation, worry, sickness and death resulting from flood devastation are other important phases difficult to valuate. Aside from these intangible elements, vexatious questions are encountered in determining the amount of injury done to material objects. It is not always clear, for instance, whether the original cost of a damaged structure or the cost of the new one which replaces it is the correct measure of the damage, and only a careful consideration of individual cases will solve such questions.

The canals which were built at great cost in the first half of the last century, paralleling the principal rivers, were partly destroyed time and again by the devastating force of floods; and the continually recurring damages of this kind contributed in no small measure to their abandonment. For more detailed accounts of the history of the Pennsylvania canals the reader is referred to Part IX on Navigation. The railroad companies profited by the unfortunate history of the canals and by their own experience where their tracks were located on the towpaths, and relocated on higher ground to be out of the reach of high water. This at first was not always accomplished, and the great floods which occurred 20 or 30 years ago were marked by havoc to railroad lines.

Direct losses sustained by railroad companies consist in cost of detouring trains, repairs to equipment, structures, signal systems, wires, road-beds, bridges, culverts and tracks. Reconstruction charges are high because the work is done under stress. Indirect damage consists in loss of business, due to suspending freight shipments, and the diversion of passenger traffic over competing lines, items which are not readily estimated. Rebuilding or raising of embankments carries with it an increased cost of maintenance over long periods, which cannot be estimated beforehand and is not, therefore, included in damage estimates.

The flood of June 1, 1889, damaged the Pennsylvania Railroad System about $5,000,000 and since that time much has been accomplished in elevating this system above flood lines. At more than 60 locations, varying from less than $\frac{1}{4}$ of a mile to 7 miles, the tracks have been raised from 1 foot to 17 feet, averaging about 3 feet. Systematic

Conewango Creek
RIVER
ALLEGHENY
Wilbunne Oil Works
Seneca Oil Works
U S Pipe Line
City Garbage Co
Warren Axe Wks
Glade Oil Works
Conplanter Refrig Co
Mile Island
PENNSYLVANIA R R
LEVEE
STREET
AVENUE
MAIN
PARK
CRESCENT
LEGEND
Frame Buildings
Submerged Area March Flood 1913
Masonry Buildings
WATER SUPPLY COMMISSION OF PENNSYLVANIA
WARREN, PA.
SHOWING AREA FLOODED
March 27th 1913
SCALE IN FEET

North Branch Susquehanna River Flood of March 28, 1914, showing Erosion of Landon Street, Westmoor

work in raising tracks and bridges is gradually bringing the principal railroad lines above the reach of floods.

Unlike the railroad systems, towns and cities have done little to improve their condition, and in many localities the value of improved property has depreciated on account of repeated inundations.

The history of floods is replete with instances of towns plunged in darkness and left without water supply, street car or railroad service in the midst of calamitous inundations. The character and extent of individual damages suffered in different towns vary widely. Easton, at the confluence of the Lehigh and Delaware rivers, is exposed to frequent inundation, but suffers comparatively little, for when high water is expected prompt action is taken in the flood zone and furniture and goods are moved above flood heights. In other localities districts are inundated every few years without seemingly awakening the inhabitants to a realization that they have located in the natural path of floods. Conspicuous instances are the Fifth Ward of Meadville, and the district of Westmoor, opposite Wilkes-Barre. Nothing short of costly protective works will render these localities permanently safe from the ever-recurring devastations to which they have placed themselves liable. The damage at Westmoor is an excellent illustration of the powerful erosive forces created by placing buildings in the pathway of flood waters. Normally, floods passed over the flats with low velocities, depositing silt and causing but little erosion, and this condition still exists where there are no buildings or raised roadways. At Westmoor the houses restrict the flow to the streets and narrow passages between them, thereby creating high velocities which are destructive. The flood of March 1914 undermined and transported concrete sidewalk slabs, stripped all surface material from macadam streets, eroded yards, and in one instance rolled the sod on a lawn like a carpet. Lack of authoritative flood data available to the public has been responsible in great measure for buildings being placed in hazardous locations, and for the supine indifference displayed in obstructing stream channels with encroachments.

Factories and mills are among the principal sufferers from flood damage, and among them are some of our largest industrial enterprises. Level building ground in close proximity to shipping facilities, unlimited water supply and a ready means for disposing of trades waste are inducements which have prompted industries to seek river front locations. Since the decline of navigation and the introduction of piped water supplies and sewer systems, these considerations have diminished in importance, and a river front as a factory site is not as essential today as it was half a century ago; but industries once established rarely change their location. The tenacity with

which man has maintained industries, dwellings and other improvements within flood zones has a paramont bearing upon the nature and extent of flood damage. At Easton the Ingersoll Rand Company removed its plant from the flood swept bottom lands of the Lehigh River to the heights at Phillipsburg, N. J., but instances of this kind are the exception rather than the rule.

Nearly all principal lines of industry have been heavy flood sufferers. At factories and mills, damage to plant, loss of output and of wages to employes can be readily determined, and sometimes total large amounts. Aside from direct damage by water, losses may result indirectly through non-arrival of fuel or raw materials by reason of impaired transportation facilities. Some kinds of plants are more susceptible to damage by water than others; thus, the plants of the Pittsburgh Plate Glass Company on the Allegheny River were damaged to the extent of several hundred thousand dollars during the flood of March 1913, while the textile mills at Manayunk, on the Schuylkill River, though periodically inundated, suffer on the whole but small monetary losses. Few of the latter maintain any costly machinery on their ground floors, while the glass company's furnaces and equipment cannot be raised above the ground and become more or less complete losses at such time. Sand and mud play prominent parts in damaging machinery and raw and manufactured articles. After the flood of February 28, 1902, the Ingersoll Rand Company expended more than $50,000 in removing mud and in taking down, cleaning and re-erecting $1,000,000 worth of machinery. Great damage has resulted to iron industries by the flooding of works and blast furnaces; losses from this source during the March 1913 flood on the Shenango River were especially severe.

In the anthracite districts, notably along the upper Schuylkill and Lackawanna rivers, collieries have repeatedly been filled with flood water and thereby rendered idle over long periods. During the torrential rain of July 24, 1912, in the coke regions in Fayette County, a number of coal mines were deluged by flood water from small streams, and 20 miners were drowned. Extraordinary losses were sustained in the oil regions during the floods of 1865 and 1892, when thousands of barrels of oil were swept down the Allegheny River. While the lumber industry on the Susquehanna River was at its height, enormous losses in logs were reported on the West Branch, during the floods of 1847, 1861, 1875 and 1889. Similar losses occurred on the Allegheny and Clarion rivers, Red Bank Creek and the Lehigh River.

The great "Pumpkin Flood" of November 10, 1810, which reached a stage of 32.0 feet at Pittsburgh, flooded an area in the downtown district practically identical with that inundated in 1907, showing

West Branch Susquehanna River at Williamsport, showing Hepburn Street after Flood of June 1, 1889

that in the course of nearly a hundred years little had been done in Pittsburgh to raise the low-lying district above flood level. Had Pittsburgh exercised due foresight 50 years ago all of the low ground referred to could have been filled in and brought above the highest known flood elevations, with possibly little more inconvenience or expense than were involved in the cutting of the "hump" district a year ago. Under present conditions it can be undertaken only with difficulty and at excessive cost, and serves as an object lesson emphasizing the importance of filling low grounds and making provisions against high water in growing communities before districts become too densely occupied.

Damage to personal property in residential districts rarely exceeds small amounts, being mainly confined to real estate. Flooded cellars, though causing discomfort and inconvenience, rarely represent material monetary losses. A painstaking canvass of flood damage made in the residential district of Westmoor after the flood of March 1914 reveals a total loss of $27,000, of which about $15,000 was sustained by two contracting firms, leaving a total of $12,000 as the aggregate losses to 342 properties, 338 of which were residences, being an average of about $35 per residence, the major part of which constituted damage to sidewalks. The water averaged 3.5 feet deep on the streets and did little damage to house furnishings. When water enters houses much damage results to wall paper, plastering and furniture not readily removed. The statistics in Tables Nos. 20 and 21 for the 1913 flood on Shenango River shows that damage of this kind was particularly heavy in New Castle and Sharon.

Few things in the history of flood damage stand out in bolder relief than the appalling losses in bridges. Millions of dollars have been literally wasted in the construction of bridges which lacked either capacity to pass floods or the necessary stability to withstand their destructive forces. Failure to provide substantial and deep foundations for piers and abutments, with few exceptions, has been traceable to faulty design or mistaken economy. Failure to place superstructures high enough to clear not only maximum stages but ice and debris as well, has been and still is a common defect, attributable sometimes to unavoidable physical conditions, limiting the height of the structure sometimes to ill chosen sites, and frequently to poor design and economy. No less serious than the damage to bridge structures is the havoc wrought to property through inundation by backwater from bridges built with insufficient openings; the numerous abuses of this kind which have come about through absence of statutory supervision in the past will require many years to correct. Many splendid bridges have been carried out by floating spans from wrecked wooden or steel bridges above, and

the large losses which have resulted from this source alone emphasize the importance of replacing bridges which are low or otherwise unsafe with adequate structures. Since 1897, the Commonwealth has expended, under the provisions of the Acts of June 3, 1895, and April 21, 1903, nearly $3,500,000 for the reconstruction of county bridges destroyed by floods, which affords some conception of the enormity of damage to bridges in this State.

Agricultural interests are sometimes benefited by inundation through deposits of alluvial material, but when floods occur during the crop growing or harvesting seasons, great losses are inflicted; and when fields are covered with deposits of culm and slate, as has frequently happened along the streams in the anthracite region, or with deposits of gravel or silt brought down by torrential streams, the crop producing value of the soil may become permanently impaired. For more detailed information regarding the wasting of culm into streams and the evils resulting from it, the reader is referred to Part X on Culm. Certain floods occurring in the fall have, by reason of the large number of pumpkins which they washed away, been known as "Pumpkin Floods."

The caving and wearing away of banks frequently progresses at alarming rates during flood stages and results not only in serious losses of land but is accompanied by the formation of bars in the channel downstream, where changes in velocity cause the current to redeposit the eroded materials. This twofold evil, if permitted to continue unchecked, eventually leads to the formation of abnormally wide and shallow river channels and the building up of numerous islands.

A serious aftermath following inundation of densely populated areas is increased sickness and death rate, brought about by exposure and unsanitary conditions.

Flood Forecasting

In order to reduce damage, and especially loss of life, by floods, the Legislature passed an act approved May 23, 1913, authorizing the Water Supply Commission to issue flood warnings and maintain gaging stations necessary for that purpose. The act provides:

"Whereas, The recent flood conditions have demonstrated the importance and necessity of establishing and maintaining gauging stations on the streams within the Commonwealth of Pennsylvania, in order that freshet and flood conditions may be telegraphed and telephoned to certain municipalities, where flood damage is likely to be caused, forecasting as near as may be the probable maximum gauging heights expected to be reached, and the probable time of the arrival of such gauge heights; therefore,—

"Section 1. Be it enacted, &c., That the Water Supply Commission of Pennsylvania is hereby authorized to establish and to maintain such gauging stations on the principal rivers and tributaries thereof as, in the judgment of the Commission, may be necessary for the determination of the daily height of water in such streams and tributaries thereof, as well as the amount of water flowing therein.

"Section 2. The Commission shall, during freshet and flood conditions, issue bulletins, to be telegraphed or telephoned to such municipalities in the Commonwealth where flood damage is likely to be caused, forecasting the probable maximum gauge heights expected to be reached, and the probable time of the arrival of such gauge heights.

"Section 3. The sum of ten thousand dollars, or so much thereof as may be necessary, is hereby specifically appropriated to the Water Supply Commission of Pennsylvania, for the purpose of carrying into effect the provisions of this act."

The flood warning service, though in operation less than two years, has demonstrated its ability to make accurate and timely forecasts; and its value, estimated in terms of property and lives saved, is likely to exceed many times its cost of operation. The perfecting and extending of the flood warning service are worthy of every possible encouragement, and should in a short time make Pennsylvania the leader in this respect.

AMELIORATION OF FLOOD CONDITIONS

In nearly all localities where periodic flood damage is occasioned, the original conditions, bad as they were, have been aggravated by the recklessness with which bridge abutments and piers have been allowed to encroach upon river channels; with which railroad companies have been permitted to build embankments across flood plains; with which fills along river banks have narrowed the streams, and with which culm and other trades waste are steadily decreasing the capacities of stream channels.

Intelligent action has been severely handicapped, not only by lack of reliable information regarding height and frequency of floods, but also on account of interference with works built by man.

Many localities have faced such problems for years without being able to obtain permanent relief. Statutory supervision of stream channels was inaugurated seven years ago, and is preventing new encroachments, but can accomplish little toward remedying the earlier errors. The situation is so complex that little has been accomplished in Pennsylvania toward lessening flood damage. Channel restrictions, caused by numerous encroachments, increase the height and, therefore, the destructiveness of floods; and discharges which formerly caused harmless stages now overtop the banks and inundate valuable property. So general is the need for flood abatement in these valleys that little permanent relief can be obtained except through comprehensive treatment of the streams. The ex-

pediency of providing flood control works for localities which suffer only during extraordinary floods at long intervals must depend in large measure on considerations pertaining to future growth and needs. Flood conditions may be ameliorated by channel improvements, dikes or other methods, singly or in combination, according to circumstances.

Channel Improvements

The capacity of a stream for discharging flood waters may be increased by different methods, usually designed to afford local relief only.

Straightening the alignment by means of cut-offs, or shifting portions of the channel, is advantageous where it can be done without incurring costly land damages or seriously interfering with the natural profile of the stream bed. This method is limited in its application, particularly in densely populated valleys.

Dredging in large rivers is a costly method, productive only of moderate increases in capacity, and the results are rarely permanent, removing as it does the effects without striking at the roots of the sedimentation evil. Small streams, however, may be greatly improved at reasonable cost by dredging, especially when done in conjunction with improvements for the prevention of future deposits.

Removal of obstructions in stream channels is desirable where it can be reasonably accomplished. Obsolete bridge piers, piles, fragments of coffer dams, dumps and bars of cinder, culm and other industrial waste block the channel of many a stream, and at time of flood they impede the flow and create abnormal stages. Such obstructions rarely fulfill a useful purpose, and their removal as a rule involves labor cost only. In replacing existing structures no opportunity should be lost to improve their design in so far as it relates to obviating channel restrictions.

Bank protection by means of masonry walls, revetment and riprap of a durable nature is useful in promoting greater velocities and increasing channel capacity, while it also prevents bank erosion. This method serves a double purpose, and can, therefore, usually be made to justify its high cost. At a few places bank protection has been provided, and filling low ground is gaining favor, while in occasional instances towns have been raised bodily above flood level. At Wilkes-Barre and Sunbury the low-lying districts along the river fronts subject to inundation have been converted into parks, and a twofold benefit has accrued.

Of equal importance with channel improvements is the prevention of flood damage by protective measures. The raising of railroad grades, highways and bridges above highest known flood levels of late years has been an important step in this direction. At Pitts-

burgh, on the north side of the Allegheny several miles of streets have been raised above high water of 1907, the fills at some points being 14 feet in height; and funds have been provided to continue this work. In the business section of Pittsburgh preparations are being made to raise some streets above a 35.5 foot stage. Wherever practicable, property susceptible of being damaged should be removed from within flood zones, or where this is impossible it should be protected by dikes or walls. Relief rom flood damage can be secured by municipalities in looking after the proper maintenance of all stream channels within their limits, preventing the deposition therein of trades waste and debris and requiring proper use of the banks. Regulations of this kind would be similar to those now in force for cleaning and maintaining streets, and not only would be salutary in promoting sanitary conditions and decreasing danger from floods, but could be enforced to better advantage by local than by State authorities. Much could be accomplished through intelligent cooperation between city planning commissions and the Water Supply Commission with a view to improving water-ways and creating parkways in flood zones, and in this manner transform malodorous channels and unsightly premises bordering on them into attractive and healthful pleasure resorts, at the same time providing unobstructed waterway for flood flow.

Dikes

Protecting land against inundation and increasing the capacity of river channels by dikes is the most ancient and most efficient type of river improvement, and unlike other methods is capable of indefinite extension, being applicable to entire river systems as well as to isolated localities. If properly built and maintained dikes can be made secure, as illustrated by their successful use in foreign countries over long periods. Where they raise the height of the water considerably above the adjacent lands, difficult problems arise in disposing of sewage and in controlling backwater on tributaries. Existing improvements, particularly bridges and railroad grades, may prove unsurmountable obstacles in laying out efficient dike systems. Aside from their double function of preventing overflow and increasing channel capacity, they do not, like reservoirs, lend themselves to the utilization of water for other beneficial purposes. Their ordinarily high cost would, therefore, in most cases be an assessment against the lands protected and cannot be shared by a variety of interests as in the case of reservoir costs. As against these objections, however, stands the fact that dikes afford quicker relief against overflow than any other method.

Reforestation

As a means of reducing flood flow, reforestation is of distinct value on two accounts. Forests prevent excessive erosion of the hillsides and so keep the stream channels from being filled with silt, and they exert a marked equalizing influence on the run-off resulting from ordinary rainfall. Forests are not capable, however, of sensibly reducing the height of great floods which result from long continued excessive precipitation, or from spring rains. Their absorptive effect is limited, rarely amounting to more than a fraction of an inch of rainfall, while the precipitation which produces great floods is in the form either of summer rains, amounting to six or more inches of uninterrupted precipitation, or of winter and spring rains, falling upon snow or saturated ground. This is substantiated by the fact that great floods were as severe and frequent before the days of timber cutting as they are at present. To produce forest growth, and more particularly the litter of the forest floor which is its principal factor in absorbing and retarding run-off, long periods of time are required. Reforestation does not, therefore, provide quick relief in any event. The preservation and proper use of the forests and reforestation of waste lands are beneficial measures which should be encouraged, for the reason that the influence of the forest on flood flow is in the direction of mitigation.

METHODS OF FLOOD CONTROL

Flood control is essentially a matter of meeting existing conditions and of planning in anticipation of future development, and, like the conservation of any natural resource, should be treated as a business proposition, in which the expenditures should in a large measure be commensurate with the benefits sought. It is not capable of solution by empirical formulae or stereotyped methods. The method of control to be adopted should depend upon the circumstances of the case, and take cognizance of all other uses of water, present and prospective, which may be involved. Because of the complexity of such problems, no one method of flood control can be applied to all cases. The magnitude of floods to be provided for depends on the value of property to be protected. It is necessary to distinguish between flood control works effecting local relief and comprehensive treatment of entire streams.

Damage by floods is, with few exceptions, restricted to specific localities, which, on account of natural as well as artificial conditions, are susceptible to inundation. Conspicuous examples of this kind are: the Lower Allegheny River, including Pittsburgh; the North Branch Susquehanna River, from Pittston to Nanticoke; and French Creek at Meadville. It cannot be claimed in these instances that the streams mentioned are troublesome throughout their lengths, and it would be manifestly unreasonable from an economic standpoint to regulate them from source to mouth for the purpose of ameliorating flood conditions at a few localities if relief can be obtained through other means. In contrast are the flood conditions existing on Turtle Creek, the Beaver and Shenango rivers and on the Lehigh River, where flood damage occurs nearly their entire lengths.

About forty years ago occasional comments were heard regarding the effect of extensive timber cutting on run-off; and the idea that deforestation was largely responsible for increasing destructiveness and frequency of extraordinary floods rapidly gained in popularity. Of late years public opinion has gradually realized that many other factors enter into the matter, and that floods can be divested of their destructive character by intercepting portions of their flow in suitable reservoirs, by protecting low-lying areas by dikes and improving natural water-ways. As each succeeding inundation takes a greater toll from the increasing amount of property placed in its path, so the need for flood control is becoming an issue of growing importance.

Reservoirs

The principal method of flood control is by means of reservoirs designed to decrease the excessive height and destructive violence of floods by temporarily storing a part of their flow. To be efficient, reservoirs should be so located and distributed as to control the run-off from large portions of the drainage area tributary to the stream to be regulated, and their capacities must be sufficient to reduce floods of great intensity as well as of long duration. Since the protection afforded by a reservoir decreases as the distance to the point to be protected increases, and good reservoir sites are not always available where most needed, flood reduction by this method is fraught with many practical limitations. The rivers of Pennsylvania, generally speaking, possess characteristics which adapt them to flood reduction by means of reservoirs. Unfortunately there are many good reservoir sites in Pennsylvania which cannot be utilized owing to the presence of railroads and communities within them, and in others real estate values are so high as to make their cost prohibitory. The

utilization of reservoirs for water supply, power or navigation in conjunction with flood detention has frequently been proposed, and has met with theoretical objections. Nevertheless, the Commission deems the plan practicable and deserving of favorable consideration. The cost of reservoirs used for more than one purpose should be shared by the beneficiaries, rendering such reservoirs more practicable commercially than those used for single purposes.

Impeding or detaining reservoirs operate automatically, and no reliance need be placed upon human vigilance for their proper operation. The automatic action is effected by providing the dam with one or more outlets, so placed as to discharge under varying hydrostatic heads, and so proportioned that the greatest discharge through them will not exceed a predetermined allowable maximum. In this manner small floods are permitted to pass readily, while during great floods the object is to detain all discharge in excess of the allowable maximum and to gradually let this water out as the flood subsides. Detaining reservoirs possess the advantage of always having the full extent of their capacity available for flood reduction and being comparatively free from silt. They are particularly adapted where protection is sought against floods of extraordinary magnitudes and rare occurrence, but share the great drawback common to most reservoirs used solely for flood detention, as during the long intervals between floods they represent an idle investment which cannot be made to contribute to the low water flow or serve any other useful purpose. This objection loses its potency where the lands consist of marsh or are otherwise of low productive value. Detaining reservoirs have been in successful use in a few localities in Europe, but so far have not been tried out in the United States.

Controlled reservoirs differ from the preceding by depending upon intelligent attendance for the regulation of the discharge through gate-controlled orifices. Where large volumes must be passed under high heads the gates or valves become unwieldy and present many structural difficulties. Moreover, hand operation of such large appliances is extremely laborious; and when run by power driven machinery defects or breakdowns may occur at critical times. By exercising caution, water may be stored in such reservoirs during certain periods of the year, to be returned to the river during the low water season; but normally storing water in them is likely to limit the purpose which they are intended to serve. To this extent they are open to the same objections which apply to automatic reservoirs, besides being dependent upon human and mechanical agencies for their control. This latter defect, however, is largely offset by the ability to so regulate their outflow as to avoid the simultaneous arrival of large volumes of water from different tributaries into the par-

ent stream, or to discharge the bulk of the flood waters from one tributary before the arrival of those from neighboring ones. In this respect they possess a decided advantage over the automatic type.

Any reservoir for water supply, water power or navigation is to some degree a protection against floods in the valley below, by reducing flood flow to the extent of the storage capacity which may be available at time of flood. Where the dams are on small streams controlling limited drainage areas, as is usually the case with water supply reservoirs, their flood-reductive value is of little consequence. But large reservoirs on streams fed by extensive drainage areas may have a natural absorptive effect during floods. Aside from the fact that such reservoirs are seldom full and are designed for the express purpose of storing excess water, they possess considerable detaining capacity, even after they have been filled to spillway level, which fact hitherto has not been sufficiently appreciated. It is well known that owing to the basin-like shape of a reservoir, its upper portions increase in capacity rapidly for each vertical foot of water added, and this is notably true for that portion lying above the spillway level. The efficiency of existing reservoirs in mitigating floods has been demonstrated in several instances, a recent one being that of the Elmhurst Reservoir of the Scranton Gas & Water Company, during the extraordinary flood of July 10, 1914, on Roaring Brook. Though full to spillway level at the time the storm began, it materially diminished the intensity of the flood flow by detaining a large volume of water at a critical time, and extending the discharge over a longer period than would normally have been the case. But for this action the damage to railroads and other property would have been greater. The joint utilization of large reservoirs for storage and for flood detention can be effected without interfering with their regular use, provided they are built with this in view, and provided also that the extra cost involved in making them valuable for flood detention is not made a burden to the owners but is borne by the communities or corporations who are directly benefited. Possibilities of this kind exist in some localities but have thus far received little consideration. On the headwaters of the Conemaugh River are 18 reservoirs for water supply, with a total capacity of about 14,500,000,000 gallons, utilizing run-off from approximately 206 square miles of drainage area out of a total of about 675 square miles, most of which is above Johnstown. For detailed information concerning these reservoirs the reader is referred to Part VI on Water Supply. The larger reservoirs, notably those on the North Branch Little Conemaugh River, Quemahoning Creek, Hinckston and Saltlick runs, exert an appreciable influence on the run-off after heavy rains. Had these dams been designed and built through co-operation with

the City of Johnstown and other interests along the river, with a view to adapting them for flood detention, an important step would have been taken to reduce the height of floods at Johnstown and other points in the valley. The cost to all interests so benefited would no doubt have been less than for any independent flood control works affording the same amount of protection. A careful investigation of the practicability of adapting these reservoirs to flood detention would seem well warranted. In view of the fact brought out in Part VII on Water Power, that the construction of numerous storage dams is contemplated for water power development, the Commission is of the opinion that the possibilities for securing flood water detention by this means are material and favors its adoption wherever the conditions will permit such joint arrangement.

The subject of flood control by reservoirs should not be dismissed without reference to the low dams existing on some rivers for slack-water navigation. The many pools so created exercise a material detaining influence on light flood discharge, but during great floods the dams, if not collapsible, serve to increase the height of the water.

Too much stress cannot be laid upon the necessity of planning and building flood control works in anticipation of the recurrence of great floods, rather than deferring such action until communities have suffered irreparable losses and are financially unable to construct remedial works.

Flood control works were built above Harrisburg in 1908 on Paxton Creek at a cost of $115,000, to prevent inundation of the city from that source, which is the only system of its kind in the State.

FLOOD CONTROL PROJECTS AND REPORTS

At various points in the State, investigations have been made to ascertain the possibility of ameliorating flood conditions, the most noteworthy of which are briefly described below. Some of these have been made by the United States Government, some by the State and several by the cities which have been damaged. Unfortunately, there have as yet been no construction results from any of them, except at Harrisburg, but each has played a part in collecting and spreading knowledge of the importance of the subject, in which the Report of the Pittsburgh Flood Commission stands prominent.

Pittsburgh

In 1898 the Chamber of Commerce of Pittsburgh became active in advocating the use of storage reservoirs for flood control and its efforts to secure amelioration of flood conditions in the upper Ohio Basin through reservoirs and reforestation, finally culminated, after the great flood of 1907, in the appointment of the Pittsburgh Flood Commission, on February 20, 1908. The Commission was directed to investigate

> "the monetary loss, character of damage and areas affected by the floods in the Pittsburgh District, and secure such other information as may be of value as a basis for further consideration of plans for improvement."

The Commission, which was composed of members of the Chamber of Commerce, City Council of Pittsburgh, Commissioners of Allegheny County, and many prominent business and professional men, made comprehensive studies, the results of which are set forth in a voluminous report published in 1912. Surveys were made of the three rivers in the Pittsburgh District and of 44 reservoir sites within the watershed above Pittsburgh, as well as extensive stream gaging operations, studies of precipitation, run-off and the probable effect of reservoirs in intercepting portions of the flood flow. The conclusions in brief were that Pittsburgh could be safeguarded against floods at a cost of about $20,000,000, by providing 17 reservoirs, distributed as effectively as possible over the drainage areas of the Allegheny and Monongahela rivers. supplemented by a river wall eliminating back channels at three islands. An appeal was made for Federal co-operation in the construction of these reservoirs on the plea that they would improve navigation during low stages. An investigation was accordingly made by a special Board of Army Engineers who in December 1912 reported "that the system of reservoirs proposed would be of such limited capacity that it could not be used in aid to navigation as well as for preventing floods," and that "while a more extensive system might be adopted, which could have sufficient capacity for both purposes, the cost would probably be very great," also that "a system of impounding reservoirs at the headwaters of the Allegheny, Monongahela and Ohio rivers and tributaries—would be of such small benefit to navigation that the Federal Government would not be justified in co-operating with local interests for their construction." In 1913 a proposed bond issue of $900,000 for building the protective wall along the river front failed to receive popular endorsement at the polls. Since that time portions of the city on the Allegheny side have been raised above flood height while several streets in the downtown district are to be similarly raised.

Williamsport

After the flood of June 1889 an examination was made, upon the request of the City of Williamsport, of the West Branch Susquehanna River by Major Charles W. Raymond, Corps of Engineers, under the direction of the Chief of Engineers, United States Army

> "in order to ascertain if the navigation of said river can be materially and permanently improved by the construction of embankments or otherwise; such survey also to be made with a view of ascertaining the best practicable method of confining the waters of said river, in times of great flood, to the general course of its channel."

Major Raymond's conclusion was as follows:

> "that the navigation of the river cannot be materially and permanently improved by the construction of embankments or otherwise.....that there is no practicable method of confining its waters in times of great flood to the general course of the channel,"

and that in his opinion the river was not worthy of improvement under the provisions of the River and Harbor Act of September 19, 1890.

As a result of the flood of May 1894, which on the West Branch Susquehana River was second in destructiveness only to that of 1889, a second investigation and report was made by Major Raymond and L. Y. Schermerhorn at the request of a Citizens' Committee on Flood Protection, upon possible methods of protecting the City of Williamsport against inundation. They recommended the construction of levees, removal of channel obstructions, raising and lengthening existing bridges, and changes in sewers and railroad grades, at a cost of $816,000. These recommendations were not acted upon, and nothing has been done towards protecting the City of Williamsport against inundation. In the 20 years that have elapsed, no flood approaching within 8 feet of that of 1894 has occurred.

Meadville

In 1862, the Erie Railroad obtained legislative authority to change the channel of French Creek at Meadville, Crawford County, by abandoning one of the old channels nearest the city, but the changes so made did not materially benefit the city as regards prevention of flood damage. Ten years ago the French Creek Improvement Association was formed at Meadville to find a solution of the flood problem and Col. W. L. Sibert and T. P. Roberts made an examination and report to the Association in which they recommended improvements in French Creek channel, diversion of Mill Creek and local protective works at a cost of $85,000. Nothing, however, has been done since

WATER SUPPLY COMMISSION OF PENNSYLVANIA

MEADVILLE

SHOWING PORTION FLOODED

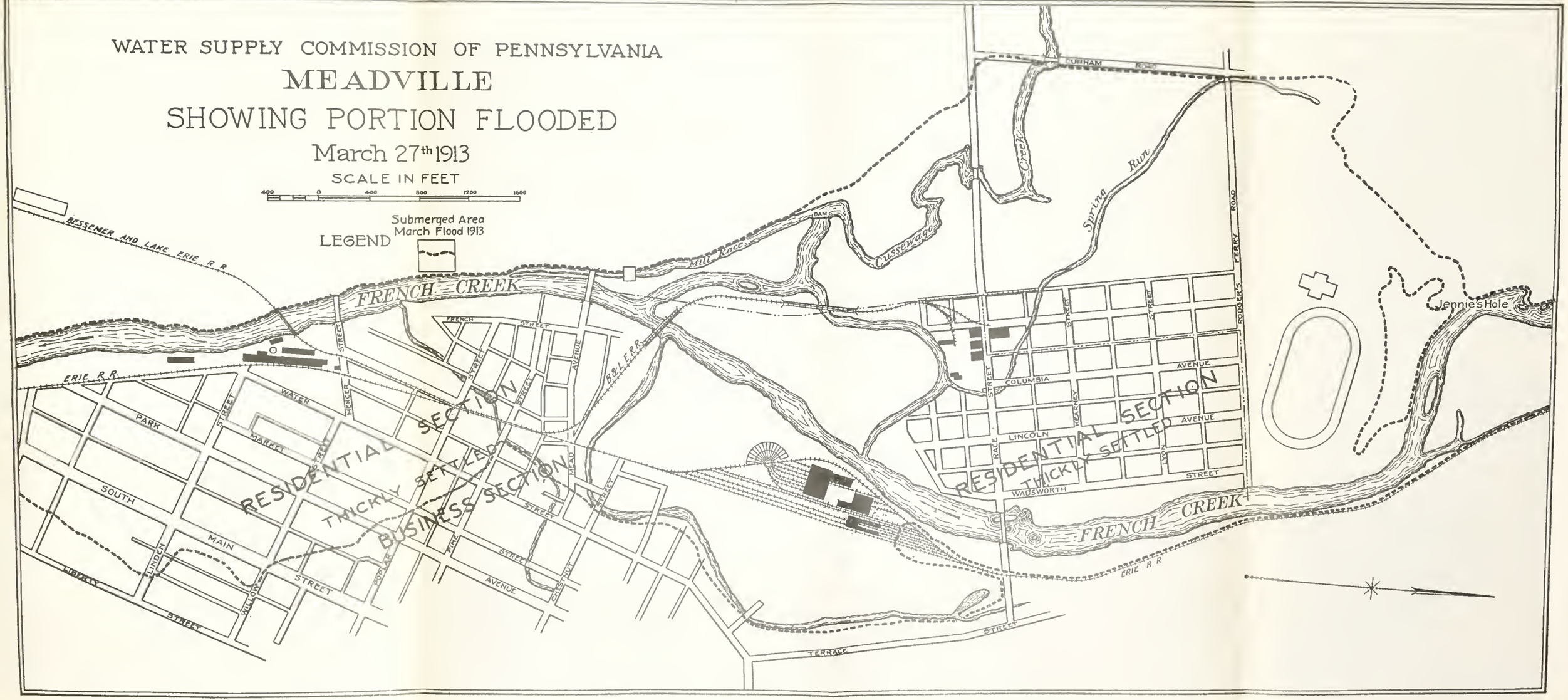
March 27th 1913

SCALE IN FEET

400 0 400 800 1200 1600

LEGEND

Submerged Area
March Flood 1913



that time, although there is a strong feeling on the part of the Chamber of Commerce, the Erie Railroad and the Bessemer & Lake Erie Railroad, that permanent protection from floods should be secured. In April 1913 the Water Supply Commission detailed an engineer to examine recently proposed schemes with representatives of the various parties interested and the results of this examination proved that the changes proposed would probably not be sufficient to provide permanent relief unless supplemented with channel improvements and levees. Nothing further has been done towards carrying out this project.

Johnstown

The memorable flood at Johnstown on May 31, 1889, followed by that of Feb. 17, 1891, caused the Board of Trade of that city to engage J. J. R. Croes, Consulting Engineer, to investigate the condition of the dams on the tributaries of the Conemaugh River above Johnstown, and to recommend improvements that should be made in the river channels to enable them to carry great floods without injury to the city. Mr. Croes submitted a report on June 15, 1891, in which he pointed out the potential danger from certain dams and the inadequate discharge capacity of the Pennsylvania Railroad stone arch bridge and at other places where serious contractions had been made in the river channels. He also made clear that without the rectification of the channel between the Baltimore & Ohio Railroad Bridge and the Franklin Street Bridge, danger from overflow at Johnstown would continue.

Turtle Creek

In the 1908 Report of the Water Supply Commission is a brief report upon the causes of and proposed methods for flood relief in Turtle Creek Valley, Westmoreland County, in which it was pointed out that flood conditions there could be materially improved by the joint action of communities and industries along the stream. Nothing was done in the matter until 1914, when the Commission made surveys and additional examinations for the purpose of determining upon an efficient plan of relief, the results of which are set forth in Part II on Turtle Creek Investigation.

Pymatuning Reservoir

The Legislature of 1911 passed an Act authorizing the Water Supply Commission to examine into the feasibility of constructing a reservoir in the Pymatuning Swamp, on the headwaters of the She-

nango River, for the purpose of regulating its flow. Though primarily intended to increase the dry weather flow for the benefit of the towns and many industries which are dependent upon the Shenango River this project will materially reduce flood flow all along the Shenango and Beaver rivers. Detailed studies and estimates made by the Water Supply Commission in pursuance of this Act, are published in its report dated December 31, 1912, which demonstrates the feasibility and desirability of constructing such a reservoir. The Legislature of 1913 directed the Commission to construct the works and appropriated $100,000. The results of additional studies and surveys will be published by the Commission in its Annual Report for 1914.

Wilkes-Barre and the Wyoming Valley

Repeated floods on the North Branch Susquehanna River between Pittston and Nanticoke have been the cause of numerous efforts to bring about some plan for preventing flood damage to Wilkes-Barre and other towns in that vicinity. Citizens' Committees worked on this problem without, however, agreeing upon any definite course satisfactory to all interests concerned. During the year 1913, Col. Lansing H. Beach, Corps of Engineers, under instructions of the Chief of Engineers, United States Army, began a detailed investigation of the channel conditions of this section of the North Branch, for the purpose of ascertaining what methods, if any, should be provided to prevent future inundation. The report of Col. Beach has not yet been made public.

Ohio River Valley

In April 1913 the Secretary of War appointed a board of officers of the Corps of Engineers to investigate and report upon flood conditions in the Ohio River Valley. The board submitted a preliminary report on May 26, 1913, followed by a final one dated February 16, 1914. The recommendations set forth therein are comprehensive, covering the main Ohio River as well as its principal tributaries, and lay particular stress on the importance of obtaining more complete data pertaining to precipitation, stream flow, channel cross sections and slopes of the principal streams and the completion of topographic maps covering the upper Ohio River Basin. The board states that until complete data of this kind, or the means of acquiring them, have been provided, it will be unable to accomplish anything of value beyond giving general advice.

Harrisburg

A report was made by James H. Fuertes in 1901 to a Citizens' Committee of Harrisburg, in which he recommended the construction of a number of municipal improvements, among them flood control works on Paxton Creek, for preventing inundation of the low portion of the city adjoining the creek. The flood works were built in 1908 at a cost of $115,000, and consist of a reservoir with restricted outlet, of capacity not exceeding that of the channel, all excess flood water being emptied into the Susquehanna River by means of a concrete conduit 2,000 feet long. The reservoir is formed by an earth dam 1,200 feet long with a maximum height of 15 feet and utilizes swamp lands. About 7,000 feet of the westerly border of the reservoir is formed by the dike of an abandoned canal. The system has proved entirely satisfactory.

New Castle

In March 1913 R. Winthrop Pratt and C. H. Milholland submitted a report to the City of New Castle with reference to protecting that city against floods on Neshannock Creek, in which they recommended that the channel be enlarged to enable it to pass, without overflowing, 25,000 cubic feet per second. The total estimated cost of $232,600 included dredging, concrete walls and dikes.

STATUTORY SUPERVISION OF STREAMS

From what has preceded it will be clear that flood damage, fundamentally, is the penalty which man pays for having ignored the natural laws which govern stream flow. This interference, whether unintentional on his part, through ignorance, or intentional through greed or indifference, was permitted to continue until seven years ago through lack of adequate supervision over streams on the part of the State Government. Not until the passage of the Act of May 28, 1907, did the State exercise any supervisory authority over the erection of structures in or along streams. The flood damage attributable to encroachments with which we are troubled today had its inception in nearly all instances long before that date, and large expenditures and long periods of time will undoubtedly be required to overcome their harmful effects. The Federal Government for many years has exercised control over the navigable rivers by virtue of its constitu-

tional power to regulate commerce between states, and as defined more specifically by Act of Congress dated March 3, 1899, which provides for Federal supervision, through the United States Army Engineer Corps, over all structures erected in navigable streams. It is important to note that the exercise of such Federal power is in the interest of navigation and is not designed to prevent flood damage or increase the flood-carrying capacities of rivers. Only through Congressional appropriation can the United States execute works for the latter purposes. The Act of Assembly approved June 25, 1913, vested additional powers in the Water Supply Commission with regard to the construction of dams, bridges and other structures in or along streams, and provided penalties for the violation of its provisions. In the short period which has elapsed since its passage the Commission has passed on a large number of applications, covering a variety of structures, and has been enabled to prevent the construction of dams of unsafe design and of serious encroachments in stream channels. Its labors have been of educational value by awakening corporation, county and city officials to a realization of the paramount importance of maintaining adequate channel capacities. The operations under the Act have demonstrated the value of continued strict statutory supervision over all streams, and have also brought out the imperative need of establishing encroachment lines along the banks of streams in densely populated districts, to serve as permanent boundary lines within which no encroachments shall be permitted. Such lines, once laid out, would make possible a close co-operation between the Water Supply Commission and municipal authorities, enabling the latter to enforce regulations with respect to the use of such lines; they would promote the intelligent planning of bridges and other structures in and along streams, and result in economy of time and prompter consideration of applications for permits than is now possible.

CONCLUSIONS

The conclusions bear on the flood problem as a whole and are intended to serve as a foundation upon which to build policies of flood control in the future. The principal conclusions are:

1. Most communities on Pennsylvania rivers are seriously damaged only by extraordinary floods which are of rare occurrence.

2. Frequent damage by floods in Pennsylvania is, with few exceptions, restricted to specific localities, which on account of natural

or artificial conditions have been rendered peculiarly susceptible to inundation.

3. On certain streams damage is inflicted along their courses by lesser floods as well as by those of great magnitude, and flood abatement on such streams requires comprehensive treatment.

4. Extraordinary floods are caused by excessive precipitation and are not attributable to artificial changes within watersheds, but artificial channel restrictions have materially increased the height and destructiveness of floods in certain localities.

5. Extraordinary floods are neither more frequent nor greater than formerly, but flood damage is increasing as a direct result of the more intensive occupation of the flood plains.

6. The occurrence of extraordinary floods is more frequent than generally believed.

7. It is possible that floods exceeding in magnitude any of the maxima shown in the tables in this report may occur, but such occurrences will be rare.

8. Flood control and water conservation for power, water supply, navigation or other purposes should, wherever practicable, be combined, and only through such combinations can commercially feasible projects be evolved.

9. No one method of flood control is advocated to the exclusion of others; methods should be applied singly or in combination, to suit the requirements of individual streams or localities.

10. Prompt betterment of flood conditions may be secured by municipalities through:

a. Periodically cleaning stream channels within corporate limits and preventing the deposition therein of solid trades waste and debris.

b. Encouraging the removal of property from flood zones and converting such areas into parks.

c. Concerted action with other municipalities and corporations in building reservoirs, channel improvements and other flood control works.

11. A general review of flood conditions in Pennsylvania accentuates the importance of:

a. Continuing strict statutory supervision over the construction of dams, bridges and channel obstructions in all streams.

b. Establishing encroachment lines in densely populated districts.

c. Extending systematic stream gaging operations to include all streams of importance.

d. Perfecting and extending the flood warning service.

RECOMMENDATIONS

Detailed studies of the causes of flood damage on individual streams or at particular localities have not been made, nor are recommendations regarding methods of relief in specific cases given.

It is recommended:

1. That flood records similar to those for the main rivers presented in this report be compiled for their tributaries, for the reason that a scarcity of data exists concerning destructive floods on such streams, which are being used more and more extensively.

2. That the Commission be authorized, in passing upon applications for the erection of dams, to investigate the feasibility of adapting the proposed reservoirs to flood detention through co-operation of municipalities and other interests which will be benefited; and that plans for flood amelioration be made with regard to future development for water power, water supply, navigation or other utilization.

3. That the Commission be authorized to investigate the possibility of utilizing existing reservoirs for flood detention by means of suitable modifications of and additions to the dams and spillways thereof, such investigations to be made wherever deemed necessary by the Commission, or at the request of interests seeking flood amelioration.

4. That the Commission be directed to establish, where required, or at the request of municipalities, encroachment lines along river banks, between which no channel obstructions shall be permitted.

5. That legislation be enacted to require municipalities to clear and maintain stream banks and channels within their corporate limits, and to be responsible to the State for deposits therein of trades waste and debris or the placing of channel obstructions wherever encroachment lines are established.

HIGH WATER RECORDS

In the following tables are listed, in chronological order by localities, the high water occurrences for some of the principal rivers. Care has been exercised to include reliable data only, and wherever figures obtained seemed questionable they either have been omitted or have been accompanied by suitable notes.

High Water Marks, Allegheny River Floods, on Residence of Dr. S. A. S. Jessop, Kittanning

Sources of Information

The records of the Water Resources Branch of the United States Geological Survey, the United States Weather Bureau and the United States Engineer Office of the War Department have been freely drawn upon, but have in many instances been corrected in the light of more recent information. The hydrographic records of the Water Supply Commission have yielded an abundance of information, and in addition access was had to records kept by railroad, canal and bridge companies and private individuals. The files of historical societies and public and private libraries have been freely consulted, and valuable data pertaining to early floods has been so obtained. The recollection of old inhabitants has been used with great caution; as a source of information in matters of this kind the memory of man has been found to be singularly defective, and in no instance are data contained in these tables based solely on it. Thanks to the many courtesies of this kind which have been extended to the Commission, it has become possible to include in these pages many valuable data which hitherto have remained unpublished.

The Commission has also drawn on a source of information which has not received in past years the attention which it deserves. These are the innumerable high water marks which exist in all parts of the State, usually on old mill buildings, factories, bridge piers, pumping plants, railroad stations and sometimes on private dwellings, in the shape of notches, chisel cuts, paint marks and bronze tablets. Such marks, when properly dated and made permanent, are eloquent witnesses of the popular interest in perpetuating the memories of great floods. At Lewistown Junction and at Bainbridge the Pennsylvania Railroad Company has erected neatly finished sandstone monuments in commemoration of the flood of June 1, 1889.

Less conspicuous, but no less important, than these artificial marks are those left by the flood waters themselves. Unpainted brick walls are peculiarly susceptible to impregnation with mud and retain the stain for an indefinite period. Plastered walls are less reliable in this respect, as the capillarity of the plastering usually causes the stains to rise above the high water level. The usual process of utilizing this class of information has consisted in obtaining the elevations of natural as well as artificial marks pertaining to the same flood in a given locality, and on the basis thereof to determine the corresponding stage of the water on the nearest river gage. In such determinations care has been taken to allow for slope of water surface, and to accept with caution isolated marks or any high water evidences not readily confirmed or authenticated. Illustrations on pages 14 and 45 show the manner of perpetuating heights of well known floods on the Delaware and Allegheny rivers.

Arrangement of Tables

The tabulated data have been arranged under the following headings:

Date—The date refers to the calendar day upon which the crest or maximum stage of high water occurred. Where two dates are given this signifies that the maximum stage occurred on more than one calendar day.

Gage Height—Under this heading is given the height of the water expressed in feet and tenths of feet on the river gage. In the case of early floods which occurred when no gages were in existence, the height is given to the nearest foot only; and where it refers to low water as a datum plane should not be relied upon to be accurate. With this latter exception all heights refer to existing gages and were derived either from direct observation on such gages or by comparison with other gage records. The latter method is possible only where records obtained at two different points on a river overlap a sufficient length of time to make possible a comparison of many different stages. Such comparison has been made by plotting the readings obtained simultaneously at the two gages on cross section paper as abscissas and ordinates respectively, and drawing a line through the plotted points representing the average relation between the gages. In this manner any given stage at one place may be obtained in terms of the other. This method, of course, is applicable only to gages so situated that no large tributaries empty into the stream between them, as under such conditions no permanent relation can be expected to exist. The maximum or crest stage is given in the tables wherever it was possible to determine it, the gage height being followed by the letter "c", to denote "crest." Heights which are not so marked do not represent crest stages but are either single gage readings obtained at a fixed hour, as in the case of the Weather Bureau observations, most of which are made at eight o'clock in the morning, or they represent the mean of two or more daily readings, as in the case of the United States Geological Survey records. The amount which such heights lack from being the maximum or crest stage may vary from a tenth of a foot to several feet, and can frequently be determined with a fair degree of accuracy. The Commission has made use of a convenient method for this purpose, consisting of plotting on cross section paper the gage readings for the entire period covering the rise and fall during a given flood. A line projected through the plotted points results in a hydrograph, from the shape of which the probable crest height of the flood may be determined within small limits of error. Knowledge of the shape of flood hydrographs for the particular stream under consideration is necessary in order to do this intelligently, but may readily be acquired

by plotting hydrographs of floods which were observed in detail. The words "Estimated from hydrograph" have been used to denote flood crests determined by this method.

Discharge—The third column gives the discharge corresponding to the gage height indicated in second column and is expressed in cubic feet per second, denoted throughout this report by the term "second-feet." The discharges have been derived mainly from the hydrographic records of the Water Supply Commission, and in part they are based on data published by the United States Geological Survey and are given to three significant figures. The tables for Easton, on the Delaware River, and Warren, on the Allegheny River, do not include discharges, there being none available. Discharges are omitted whenever high water stages were caused by the gorging of ice, since at such times no relation exists between gage height and discharge. For early floods, discharges are taken from rating tables applying to existing conditions, as little is known regarding the changes which have taken place in stream channels, and no intelligent allowance can be made for such changes. Such discharges are probably low and should be accepted as approximate.

Discharge per square mile—Under this heading is given the run-off or yield from the drainage area in second-feet per square mile, the figure being obtained by dividing the discharge in second-feet, by the drainage area in square miles. The latter is given in the heading of the table, and is expressed to three significant figures. Run-off figures are particularly useful for comparing the characteristics of stream flow in different parts of the State, and as affording a convenient basis for engineering computations relating to river hydraulics.

Notes—Under this heading are given explanatory notes and memoranda. The term "ice gorged" has been used to denote backwater caused by ice jams.

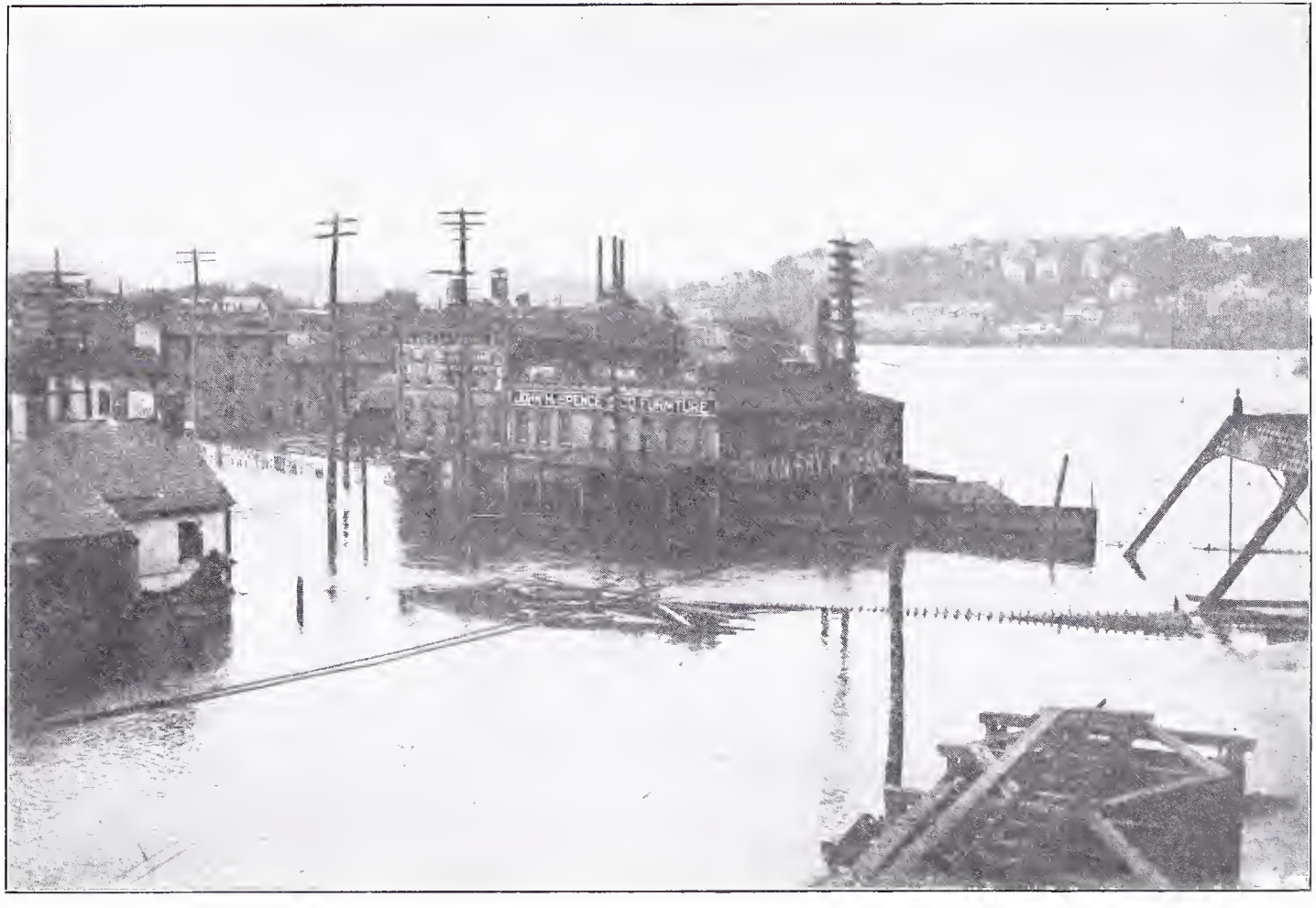
Early floods—The subject-matter in each table has been subdivided under the different sources of information from which the data were obtained. The first subdivision, headed "Early Floods," contains all high water occurrences of which mention could be found previous to the time when regular river stage observations were commenced. These early data are necessarily more or less scattering, but include as a rule those floods which, on account of unusual height or destructive character, are notable and are of value in determining periodicity. Among them will be found many instances where mere dates are given and nothing definite is known with regard to the height attained aside from the fact that it was extraordinary. Such data, incomplete as they may be, are valuable, as they help to extend our knowledge of floods and serve as beacons to assist in further research.

Minimum annual high water stage—That portion of the tabulated data which is derived from consecutive daily gage readings contains,

in chronological order, all high water occurrences which have equalled or exceeded the "minimum annual high water stage" for the given locality, which may be defined as being that particular high water stage which has occurred or has been exceeded at least once in each calendar year. It is most readily ascertained by listing the maximum high water for each year of the record and selecting the minimum. This use of the minimum annual high water stage accomplishes a twofold purpose: first, it places all flood records on a uniform basis; second, it furnishes the logical starting point for determining the periodicities of high water occurrences of different degrees of magnitude.

Delaware River at Easton, Pa., and Phillipsburg, N. J.

Several gage records kept in this locality have been published in Table No. 1, all heights being referred to elevations above mean tide at Sandy Hook. The first record was kept by Mr. Peter Snyder, at his tannery, located on Bushkill Creek, at the foot of Third Street, on the site now occupied by Fassett's garage. His observations cover the period 1777 to 1814 and were made on backwater from Delaware River. The datum of his gage is not definitely known, but probably coincided with the bed of the creek opposite the gage, the elevation of which at the present time is 164.4 feet and this figure has been tentatively used as the datum. A copy of the original Snyder record has been preserved by Mr. B. M. Youells, through whose courtesy it has been made available for publication. The second record was obtained at the Delaware River bridge, between Easton and Phillipsburg, and is from the original kept by Mr. William Green, collector for the Bridge Company. When in 1895 the bridge was replaced by a new structure the gage was taken out, and no record has since been kept at that location. The flood heights for 1896 to 1903, inclusive, are referred to the datum of the bridge gage, which is approximately 155.8 feet above mean tide at Sandy Hook. Those for March 2, 1902, and October 10, 1903, were derived from existing high water marks. Since August 1, 1904, a daily record has been kept at Phillipsburg, N. J., by the United States Weather Bureau, the gage being on the



Delaware River Flood of October 10, 1903, showing South Third Street, Easton

Lehigh Valley Railroad Bridge at Lehigh Junction. The elevation of its zero is 157.2 feet. No constant relation exists at either of these gages between height and discharge, for the reason that backwater is caused by the confluence of the Lehigh and Delaware rivers and discharge are not, therefore, included in this table. The Phillipsburg gage is below the mouth of the Lehigh River and approximately 1,500 feet downstream from the Delaware Bridge. The mouth of Bushkill Creek is approximately 1,600 feet upstream from the latter. The flood elevations obtained at the tannery gage were probably several feet higher than the corresponding stages at the bridge gages. The minimum annual flood stage based on the Weather Bureau record is 11.1 feet.

TABLE No. 1. *Record of High Water on Delaware River at Easton, Pa., and Phillipsburg, N. J.*

Date.	Gage Height.	Elevation.	Notes.
	Feet.	Feet.	
EARLY FLOODS.			All data approximate.
1687,	.....	.....	Phineas Pemberton's letter of February 27, 1692.
1692, February,	.....	.....	Phineas Pemberton's letter of February 27, 1692.
1731, February,	.....	.....	Hazard's Register, 1828, Volume II, page 23.
PETER SNYDER'S RECORD.			Datum: Bottom of Bushkill Creek, 164.4 feet (Sandy Hook).
1777, October 27,	23.2 c	187.6 c	
1781, May 9,	25.5 c	189.9 c	
1783, February 28,	24.4 c	188.8 c	
1785, March 17,	26.9 c	191.3 c	
1786, October 4,	25.2 c	189.6 c	
1814, April 1,	24.4 c	188.8 c	
MISCELLANEOUS SOURCES.			
1829, April,	.....	174.0 c	Approximate.
1832, March 13,	.....	179.0 c	Caused principally by Lehigh River; water 8 feet on Lehigh Dam according to Hazard's Register.
1836, April 11,	.....	186.0 c	Easton Democrat and Argus of April 14, 1836, claims water came within a few inches of 1814 flood.
1840, November 4,	.....	.....	
DELAWARE RIVER BRIDGE RECORD.			Datum: 155.8 feet (Sandy Hook).
1841, January 8,	32.2 c	188.0 c	According to Easton Free Press height was 35 feet.
1845, October 13,	22.6 c	178.4 c	
1846, March 16,	27.8 c	183.6 c	
1850, September 2,	.....	.....	
1857, May 3,	24.3 c	180.1 c	
1862, June 5,	32.1 c	187.9 c	Caused principally by Lehigh River.
1868, July 20,	24.8 c	180.6 c	
1869, October 15,	28.6 c	184.4 c	
1875, April 9,	27.5 c	183.3 c	
1878, October 27,	22.6 c	178.4 c	
1878, December 11,	28.6 c	184.4 c	
1882, March 2,	23.1 c	178.9 c	
1885, April 14,	21.0 c	176.8 c	
1886, January 3-4,	18.0 c	173.8 c	
1886, February 14,	23.2 c	179.0 c	Ice gorged.
1886, April 1,	21.2 c	177.0 c	
1886, June 6,	20.2 c	176.0 c	
1888, September 18,	22.1 c	177.9 c	
1893, March 12,	21.0 c	176.8 c	
1895, April 9,	27.5 c	183.3 c	
1896, February 6,	.....	.....	

TABLE No. 1—Continued

Date.	Gage Height.	Elevation.	Notes.
	Feet.	Feet.	
DELAWARE RIVER BRIDGE RECORD—Continued.			
1896, March 1,	20 e	175.8 e	ice gorged, approximate.
1900, March 2,	20 e	175.8 e	Ice gorged, approximate.
1901, December 16,	31.1 e	186.9 e	Easton Daily Free Press, December 16, 1901.
1902, March 2,	.....	185.3 e	Determined from high water marks.
1903, October 10,	.....	192.5 e	Determined from high water marks.
UNITED STATES WEATHER BUREAU RECORD.			Datum: 157.2 feet (Sandy Hook).
1904, October 22,	11.1 e	168.3 e	
1905, January 8,	11.2	168.4	
1905, March 26,	14.5 e	171.7 e	
1906, March 5,	13.6 e	170.8 e	
1906, April 16,	16.2 e	173.4 e	
1907, November 8,	14.1	171.3	
1907, December 11,	18.2 e	175.4 e	
1908, February 16,	18.5 e	175.7 e	
1908, March 30,	11.7	168.9	
1909, January 7,	14.1 e	171.3 e	
1909, February 21,	16.6 e	173.8 e	
1910, January 23,	17.5 e	174.7 e	
1910, March 2,	17.0 e	174.2 e	
1910, April 27,	11.4	168.6	
1911, March 29,	12.0 e	169.2 e	
1911, June 14,	11.2	168.4	
1912, March 16,	14.6 e	171.8 e	
1912, March 30,	11.6	168.8	
1913, January 9,	13.4 e	170.6 e	
1913, March 28,	22.2 e	179.4 e	
1913, November 11,	11.7 e	168.9 e	
1914, March 29,	21.0 e	178.2 e	
1914, April 10,	12.4	169.6	

Delaware River at Lambertville, N. J.

The gage was established by the United States Geological Survey on the highway bridge between Lambertville, N. J., and New Hope, Pa., on July 23, 1897, and a record kept until April 1908, when it was discontinued on account of irregularities in the discharge of the river, caused by a low crib dam below the gage. The effect of this dam has not been appreciable on high water stages. For the period 1862 to 1895 inclusive the flood heights are referred to the gage at New Hope, the datum of which is approximately the same as for the Lambertville gage; the discharges for these years are subject to correction. The minimum annual flood stage is 9.2 feet.

TABLE No. 2. *Record of High Water on Delaware River at Lambertville, N. J. (Drainage Area, 6,860 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1687,	.....	.....	.....	
1692, February,	.....	.....	.....	
1731, February,	.....	.....	.....	
1786, October 6,	16 e	128,000	19	
1798,	.....	.....	.....	
1801,	14 e	108,000	16	
1814, April 1,	14 e	108,000	16	
1832, March,	12 e	87,200	13	
1836, April,	14.5 e	113,000	16.5	
1839, April,	14.5 e	113,000	16.5	
1841, January 8,	20 e	170,000	25	Height of 21.3 feet according to New Hope gage.
1843, October 13,	14 e	108,000	16	
1846, March 15,	17.5 e	144,000	21.0	
1862, June 8,	20.6 e	176,000	25.7	New Hope gage reading.
1869, October 15,	18 e	149,000	22	New Hope gage reading.
1873, April,	14 e	108,000	16	New Hope gage reading.
1873, October,	14.6 e	114,000	16.6	New Hope gage reading.
1873, December,	14.6 e	114,000	16.6	New Hope gage reading.
1888, September 18,	14 e	108,000	16	New Hope gage reading.
1895, April 9,	17 e	139,000	20	New Hope gage reading.
UNITED STATES GEOLOGICAL SURVEY RECORD.				
1897, December 16,	10.2 e	68,700	10.0	
1898, February 22,	9.6 e	62,500	9.1	
1899, March 14,	9.2 e	58,400	8.5	
1900, February 14,	11.4	81,100	11.8	
1900, February 23,	9.6	62,500	9.1	
1900, March 2,	13.0 e	97,600	14.2	Estimated from hydrograph.
1901, March 22,	10.5	71,800	10.5	
1901, March 28,	9.4	60,500	8.8	
1901, April 23,	9.8	64,600	9.4	
1901, May 31,	9.6	62,500	9.1	
1901, August 25,	9.8	64,600	9.4	
1901, December 16,	19.5 e	164,000	23.9	Estimated from hydrograph.
1901, December 30,	9.2	58,400	8.5	
1902, March 2,	21.2 e	182,000	26.5	Estimated from hydrograph, 20.6 feet according to New Hope gage.
1902, March 14,	11.0	77,000	11.2	
1902, March 18,	11.8	85,200	12.4	
1902, September 30,	12.1	88,300	12.9	
1902, December 23,	12.9	96,500	14.1	
1903, March 1,	15.1 e	119,000	17.3	Height of 19.2 feet according to New Hope gage.
1903, March 12,	9.9	65,600	9.6	
1903, March 24,	13.8 e	106,000	15.5	
1903, June 13,	9.6	62,500	9.1	
1903, October 11,	24.5 e	217,000	31.6	Height of 25.5 feet according to New Hope gage.
1904, February 22,	15.0	.....	.....	Ice gorged.
1904, March 27,	9.8	.....	.....	Ice gorged.
1904, October 23,	9.2	58,400	8.5	
1904, December 30,	9.4	60,500	8.8	
1905, January 8,	10.8	74,900	10.9	
1905, March 21,	11.7	84,200	12.3	
1905, March 28,	11.9 e	86,200	12.6	
1905, December 5,	10.6 e	72,800	10.6	Estimated from hydrograph.
1906, March 5,	13.2 e	99,600	14.5	Estimated from hydrograph.
1906, April 16,	13.6 e	104,000	15.2	Estimated from hydrograph.
WATER SUPPLY COMMISSION RECORD.				
1907, January 2,	10.2 e	68,700	10.0	Estimated from hydrograph.
1907, March 24,	10.0 e	66,600	9.7	Estimated from hydrograph.
1907, November 8,	12.2 e	89,300	13.0	Estimated from hydrograph.
1907, December 11,	16.2 e	131,000	19.1	Estimated from hydrograph.
1908, February 16,	14.5 e	113,000	16.5	
1908, March 15,	10.0 e	66,600	9.7	Estimated from hydrograph.
1908, March 30,	10.8 e	74,900	10.9	Estimated from hydrograph.

Lehigh River at Bethlehem

The record is referred to the gage established April 26, 1909, by the Water Supply Commission on the New Street Bridge, between Bethlehem and South Bethlehem, at the same location as the United States Geological Survey maintained a gage from September 22, 1902, to February 13, 1905. The zero of this gage is 210.64 feet above mean tide. Previous to 1909 high water readings were taken by the Lehigh Bridge Company on a gage located at the old wooden bridge and have been utilized by establishing a relation between the two gages. The zero of this gage was 213.45 feet above mean tide. The drainage area of 1,240 square miles does not include that of Monocacy Creek, which empties into the Lehigh River near the gaging station. All discharges in Table No. 3, were calculated from a rating curve which is well defined below a gage height of 14 feet. The minimum annual flood stage is 6.6 feet.

TABLE No. 3. *Record of High Water on Lehigh River at Bethlehem (Drainage Area, 1,240 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1739,	.....	.....	.....	
1747, February 28,	.....	.....	.....	
1757, July,	.....	.....	.....	
1786, October 4,	18 c	50,300	41	Height of 15 feet on Lehigh Bridge Company gage.
1819, April 4,	.....	.....	.....	
1832, March 13,	.....	.....	.....	
1836, April 11,	.....	.....	.....	
1839, January 26,	16 c	41,800	34	Height of 13 feet on Lehigh Bridge Company gage.
1840, November 4,	.....	.....	.....	
1841, January 8,	23 c	72,800	59	Height of 20 feet on Lehigh Bridge Company gage.
1850, September 2,	.....	.....	.....	Height of 17 feet above low water.
1862, June 5,	23.3 c	74,400	59.8	Height of 20 feet 6 inches on Lehigh Bridge Company gage.
1869, October 4,	23 c	72,800	59	
1892, February 8,	.....	.....	.....	
1894, May 21,	17 c	46,000	37	
1901, December 15,	17.5 c	48,000	38.7	
1902, February 28,	25.9 c	86,600	69.8	Determined from high water marks.
UNITED STATES GEOLOGICAL SURVEY RECORD.				
1902, September 26,	8.4	14,700	11.9	
1902, December 22,	12.2	26,800	21.6	
1903, March 1,	10.2	20,100	16.2	
1903, March 24,	9.2	17,000	13.7	
1903, October 10,	11.9	25,800	20.8	
1904, March 7,	10.2 c	20,100	16.2	
1904, April 2,	6.6	9,680	7.8	
1905, January 7,	10.2 c	20,100	16.2	
				No record from February 14, 1905, to April 25, 1909, inclusive.

TABLE No. 3—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
WATER SUPPLY COMMISSION RECORD.	Feet.	Second-feet.	Second-feet.	
1909, May 2,	6.6	9,680	7.8	
1910, January 22,	13.8 c	32,700	26.4	
1910, February 22,	6.9 c	10,500	8.5	
1910, March 1,	8.5 c	15,000	12.1	
1910, April 26,	8.0 c	13,500	10.9	
1911, June 14,	6.6	9,680	7.8	
1911, September 1,	7.2 c	11,300	9.1	
1912, February 22,	8.2 c	14,100	11.4	
1912, March 13,	8.4	14,700	11.9	
1912, March 15,	10.8 c	22,100	17.8	
1912, March 30,	7.0	10,700	8.6	
1913, January 4,	6.8	10,200	8.2	
1913, March 15,	6.6	9,680	7.8	
1913, March 27,	12.4 c	27,500	22.2	
1913, April 28,	11.0 c	22,700	18.3	
1914, January 31,	6.9 c	10,500	8.5	
1914, March 29,	7.1 c	11,000	8.9	

Schuylkill River at Reading

Table No. 4 is referred to two gages, that of the Schuylkill Navigation Company located at the Canal Shops on Water Street, below Spruce Street, and the one established by the Water Supply Commission on May 6, 1914, at the Penn Street Bridge. Daily readings taken at the Schuylkill Navigation Company gage have been published by the United States Weather Bureau since September 1, 1904. From a comparison of gage readings obtained at the two gages a relation has been established by means of which the height of all floods has been expressed in terms of either gage, including the earlier data derived from high water marks. The zero of the Schuylkill Navigation Company gage is 185.79 feet above sea level and that of the Water Supply Commission is 188.50 feet. The rating curve from which the discharges were calculated is not well defined above a gage height of 10 feet. The minimum annual flood stage is 5.0 feet on the Navigation Company's gage.

TABLE No. 4. *Record of High Water on Schuylkill River at Reading (Drainage Area, 900 square miles)*

Date.	Schuylkill Navigation Company gage height.	Water Supply Commission gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.					All data approximate.
1757, July 15,	15.0 c	15.0 c	37,200	41.3	Height estimated above low water.
1786, October 6,	17.3 c	17.3 c	47,200	52.5	Height estimated above low water. Berks and Schuylkill County Journal of 1850 mentions 5 feet 10 inches lower than flood of September 2, 1850.
1822, February 21,	10.4 c	10.6 c	23,600	26.2	From marks on Messersmith's Mill, quoted in Der Readinger Adler, January 12, 1841.
1839, January 25,	13.8 c	13.9 c	33,300	37.0	From marks on Messersmith's Mill, quoted in Der Readinger Adler, January 12, 1841.
1841, January 6,	15.8 c	15.8 c	40,400	44.9	From marks on Messersmith's Mill, quoted in Der Readinger Adler, January 12, 1841.
1850, July 20,	18.7 c	18.6 c	53,900	59.9	
1850, September 2,	23.2 c	23.0 c	80,000	88.9	Determined from high water marks.
1862, June 5	16.0 c	16.0 c	41,200	45.8	
1869, October 4,	21.7 c	21.6 c	71,200	79.1	Determined from high water marks.
SCHUYLKILL NAVIGATION COMPANY RECORD					
1870, April 19,	10.0 c	10.2 c	22,500	25.0	
1873, October 19,	11.5 c	11.7 c	26,500	29.4	
1877, November 9,	7.3 c	7.6 c	15,600	17.3	
1878, December 11,	6.2 c	6.6 c	12,900	14.3	
1881, February 11,	10.0 c	10.2 c	22,500	25.0	
1885, August 3,	9.0 c	9.2 c	19,800	22.0	
1889, November 20,	6.9 c	7.2 c	14,500	16.1	
1891, August 24,	12.0 c	12.2 c	27,900	31.0	
1893, May 3,	9.0 c	9.2 c	19,800	22.0	
1894, May 21,	16.8 c	16.8 c	44,800	49.8	Determined from high water mark.
1901, December 15,	11.8 c	12.0 c	27,300	30.3	
1901, December 30,	8.8 c	9.0 c	19,300	21.4	
1902, January 22,	11.0 c	11.2 c	25,100	27.9	
1902, February 28,	21.6 c	21.5 c	70,600	78.4	Determined from high water mark.
1902, December 17,	9.6	9.8	21,400	23.8	
1902, December 22,	11.9	12.1	27,600	30.7	
1903, October 10,	7.7	7.9	14,000	15.6	
1904, January 22,	8.5	8.8	18,800	20.9	
1904, February 23,	8.5	8.8	18,800	20.9	
1904, March 7,	15.0	15.3	37,200	41.3	
UNITED STATES WEATHER BUREAU RECORD.					
1905, January 7,	9.9 c	10.3	22,700	25.2	
1905, March 22,	5.2 c	5.6 c	10,300	11.4	
1906, February 22,	5.9	6.2 c	11,900	13.2	
1906, March 4,	13.2	13.3	31,300	34.8	
1906, July 3,	7.7 c	8.0 c	16,600	18.4	
1907, January 1,	7.8 c	8.1 c	16,900	18.8	
1907, March 15,	6.8	7.1	14,200	15.8	
1907, September 24,	5.7	6.0	11,300	12.6	
1907, December 11,	9.7	10.0	21,900	24.3	
1908, February 16,	13.2 c	13.3 c	31,300	34.8	
1908, February 27,	13.7 c	13.8 c	32,900	36.6	
1908, May 8,	8.6	8.9	19,000	21.1	
1908, July 23,	5.0	5.4	9,740	10.8	
1909, February 25,	5.0	5.4 c	9,740	10.8	
1910, January 22,	11.9	12.1 c	27,600	30.7	
1910, February 22,	6.5 c	[illegible]	13,400	14.9	

North Branch Susquehanna River Flood of March 28, 1913, showing Flooded Flats opposite Wilkes-Barre

TABLE No. 4—Continued

Date.	Schuylkill Navigation Company gage height.	Water Supply Commission gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Feet.	Second-feet.	Second-feet.	
UNITED STATES WEATHER BUREAU RECORD—Continued.					
1910, March 1,	5.9	6.2	11,900	13.2	
1910, April 25,	5.3	5.7	10,500	11.7	
1911, September 1,	5.2	5.6	10,300	11.4	
1911, October 2,	6.6 e	6.9 e	13,700	15.2	
1912, February 22,	6.2	6.6 e	12,900	14.3	
1912, March 13,	11.0 e	11.2 e	25,100	27.9	
1912, March 16,	7.8	8.1 e	16,900	18.8	
1913, March 14,	6.6 e	6.9 e	13,700	15.2	
1913, March 27,	12.0 e	12.2 e	27,900	31.0	
1913, April 28,	7.6	7.9	16,400	18.2	
1914, January 31,	5.3 e	5.7 e	10,500	11.7	

North Branch Susquehanna River at Wilkes-Barre

The United States Weather Bureau began taking gage readings November 1, 1890, on a staff gage fastened to a pier of the Market Street Bridge. On March 30, 1899, the United States Geological Survey established a chain gage, the datum of which was 505.3 feet above sea level. On July 20, 1910, the chain gage was superseded by a Mott gage installed by the United States Weather Bureau to the same datum, and on which the records here published are based. The intermittent record of the Weather Bureau from November 1, 1890, to March 30, 1899, has been corrected to refer to the present gage. At 18 feet the river overflows the west bank, but no material damage is inflicted until a 24 foot stage is reached. The discharges in Table No. 5 are referred to a rating curve which is well defined below a gage height of 28 feet. The minimum annual flood stage is 17 feet.

TABLE No. 5. *Record of High Water on North Branch Susquehanna River at Wilkes-Barre (Drainage Area, 9,920 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1784, March 15,	30	.....	.....	Ice gorged. Described in letter of Rev. Jacob Johnson written a few days after the flood.
1786, October 5,	29	189,000	19	According to William H. Sturdevant height was 40 feet.
1807, April,	30	202,000	20	Described in letter of James Sinton to Steuhen Butler, written in 1807.
1809, July,	20	95,200	10	
1810, November 20,	.....	.....	.....	
1819, April,	.....	.....	.....	Ice gorged.
1829, April 18,	.....	.....	.....	Flats opposite Wilkes-Barre flooded.
1831, January,	.....	.....	.....	Flats opposite Wilkes-Barre flooded.
1832, March 6,	.....	.....	.....	Ice gorged. Flats opposite Wilkes-Barre flooded.
1833, May 14,	28	176,000	18	
1841, January 6,	.....	.....	.....	
1842,	.....	.....	.....	Ice gorged. Flats opposite Wilkes-Barre flooded.
1846, March 13,	.....	.....	.....	Ice gorged. Highest water since 1807.
1850, July 19,	.....	.....	.....	
1850, Septemher 2,	.....	.....	.....	
1861, February 12-13,	.....	.....	.....	Ice gorged. Flats opposite Wilkes-Barre flooded.
1865, Mareh 18,	33.1 c	248,000	25.0	Determined from high water marks by W. V. Ingham in 1902.
1866, February,	.....	.....	.....	Ice gorged.
1875, March 16,	.....	.....	.....	Ice gorged. All bridges at Pittston destroyed.
1878, Decemher 12,	.....	.....	.....	
1889, June 1,	.....	.....	.....	Not a destructive flood along the North Branch.
UNITED STATES WEATHER BUREAU RECORD.				
1891, January 24,	26.8 c	162,000	16.3	Estimated from hydrograph.
1891, February 19,	23.5	128,000	12.9	
1891, February 27,	23.0	123,000	12.4	
1891, March 24,	18.0	78,000	7.9	
1892, January 14,	20.0	95,200	9.6	
1892, January 23,	18.0	78,000	7.9	
1892, February 26,	20.0	95,200	9.6	
1892, March 28,	17.0	70,000	7.1	
1892, April 4,	21.6 e	110,000	11.1	Estimated from hydrograph.
1893, February 16,	18.0	78,000	7.9	
1893, March 11,	28.7 e	.....	.....	Ice gorged.
1893, May 5,	22.0	114,000	11.5	
1894, March 8,	19.0 c	86,300	8.7	Estimated from hydrograph.
1894, May 21,	20	95,200	10	
				No record from May 13, 1894, to January 31, 1895.
1895, March 3,	27.0	.....	.....	Ice gorged.
1895, April 10,	21.8 c	112,000	11.3	Estimated from Towanda record.
1896, January 1,	19.0	86,300	8.7	
1896, February 7,	19.0	86,300	8.7	
1896, March 2-3,	17.0	70,000	7.1	
1896, March 21,	17.0	70,000	7.1	
1896, April 1,	24.0	133,000	13.4	
1896, October 15,	19.0	86,300	8.7	
				No record for November or December 1896.
1897, March 26,	17.0	70,000	7.1	
				No record for May or June 1897.
1898, January 16,	21.8	.....	.....	Ice gorged.
1898, April 26,	17.8 e	76,400	7.7	Estimated from hydrograph.
1899, January 7,	25.0	.....	.....	Ice gorged.
1899, March 6,	18.2 c	79,600	8.0	Estimated from hydrograph.

TABLE No. 5—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
UNITED STATES GEOLOGICAL SURVEY RECORD.				
1900, January 21,	18.8 e	84,600	8.5	Estimated from hydrograph.
1900, February 9,	17.8	.....	.....	Ice gorged.
1900, March 2,	19.7 e	92,500	9.3	Estimated from hydrograph.
1900, November 28,	22.0 e	114,000	11.5	Estimated from hydrograph.
1901, March 12,	21.5 e	.....	.....	Ice gorged.
1901, March 28,	21.6 e	110,000	11.1	Estimated from hydrograph.
1901, April 8,	18.2 e	79,600	8.0	Estimated from hydrograph.
1901, April 23,	19.2 e	88,100	8.9	Estimated from hydrograph.
1901, May 21,	17.8 e	76,400	7.7	Estimated from hydrograph.
1901, December 15,	27.0 e	164,000	16.5	Estimated from hydrograph.
1902, January 23,	18.2 e	.....	.....	Ice gorged.
1902, March 2,	31.4 e	221,000	22.3	Estimated from hydrograph.
1902, March 18,	20.4 e	98,800	10.0	Estimated from hydrograph.
1902, December 23,	18.2 e	79,600	8.0	Estimated from hydrograph.
1903, January 31,	17.7 e	.....	.....	Ice gorged.
1903, February 5,	19.5 e	.....	.....	Ice gorged.
1903, March 2,	21.4 e	108,000	10.9	Estimated from hydrograph.
1903, March 10,	19.6	91,600	9.2	Estimated from hydrograph.
1903, March 12,	19.3 e	88,900	9.0	Estimated from hydrograph.
1903, March 25,	22.4 e	117,000	11.8	Estimated from hydrograph.
1903, August 30,	20.5 e	99,700	10.1	Estimated from hydrograph.
1903, October 11,	21.7 e	111,000	11.2	Estimated from hydrograph.
1904, January 23,	20.5 e	.....	.....	Ice gorged.
1904, February 10,	25.7 e	.....	.....	Ice gorged.
1904, March 9,	30.6 e	.....	.....	Ice gorged.
1904, March 27,	22.9 e	122,000	12.3	Estimated from hydrograph.
1905, March 26,	23.4 e	127,000	12.8	Estimated from hydrograph.
1906, April 1,	17.7 e	75,600	7.6	Estimated from hydrograph.
UNITED STATES WEATHER BUREAU RECORD.				
1907, December 12,	19.8 e	93,400	9.4	Estimated from hydrograph.
1907, December 25,	18.7 e	83,800	8.4	Estimated from hydrograph.
1908, February 17,	21.8 e	112,000	11.3	Estimated from hydrograph.
1908, March 16,	21.0 e	104,000	10.5	Estimated from hydrograph.
1908, March 30,	20.2 e	97,000	9.8	Estimated from hydrograph.
1909, February 21,	18.6 e	82,900	8.4	Estimated from hydrograph.
1909, February 26,	18.6 e	82,900	8.4	Estimated from hydrograph.
1909, April 15,	17.9 e	77,200	7.8	Estimated from hydrograph.
1909, May 2,	23.0 e	123,000	12.4	Estimated from hydrograph.
1910, January 23,	19.6 e	91,600	9.2	Estimated from hydrograph.
1910, March 3,	26.1 e	155,000	15.6	Estimated from hydrograph.
1910, April 25,	21.6 e	110,000	11.1	Estimated from hydrograph.
1911, March 29,	19.7 e	92,500	9.3	Estimated from hydrograph.
1911, April 8,	17.2 e	71,600	7.2	Estimated from hydrograph.
1912, March 19,	17.9 e	77,200	7.8	Estimated from hydrograph.
1912, March 31,	22.0 e	114,000	11.5	Estimated from hydrograph.
1912, April 3,	23.2 e	125,000	12.6	Estimated from hydrograph.
1913, January 9,	20.2 e	97,000	9.8	Estimated from hydrograph.
1913, March 28,	28.5 e	182,000	18.3	
WATER SUPPLY COMMISSION RECORD.				
1914, February 1,	17.1 e	70,800	7.1	Estimated from hydrograph.
1914, March 29,	28.3 e	180,000	18.1	
1914, April 9,	21.3 e	107,000	10.8	Estimated from hydrograph.
1914, April 21,	17.3 e	72,400	7.3	Estimated from hydrograph.
1914, May 14,	21.0 e	104,000	10.5	Estimated from hydrograph.

North Branch Susquehanna River at Danville

The gage record started by the United States Geological Survey March 25, 1899, was continued from its inception to March 9, 1904, when the Mill Street Bridge, on which the gage was located, was carried away by an ice jam. The gage was re-established March 24, 1905, on the new bridge to the same datum. The rating curve from which the discharges were obtained is not well defined above a gage height of 20 feet. The minimum annual flood stage is 14.6 feet.

TABLE No. 6. *Record of High Water on North Branch Susquehanna River at Danville (Drainage Area, 11,200 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1784, March 15,	.....	.....	.....	Ice gorged.
1786, October 5,	.....	.....	.....	
1810, November 20,	.....	.....	.....	
1846, March 14,	26	.....	.....	Ice gorged. According to W. G. Yetter, Catawissa, Pa.
1850, July 19,	26	265,000	24	According to W. G. Yetter, Catawissa, Pa.
1865, March 18,	28	298,000	27	Determined from high water mark on Lower Mulberry Street.
1875, March 18,	25.5	.....	.....	Ice gorged. Determined from a bigh water mark on a house located on Foust Street.
1878, December 12,	.....	.....	.....	
1889, June 1,	.....	.....	.....	
1894, May 22,	.....	.....	.....	
UNITED STATES GEOLOGICAL SURVEY RECORD.				
1900, March 2,	15.9 e	107,000	9.6	Estimated from hydrograpb.
1900, November 28,	17.9 e	134,000	12.0	Estimated from Wilkes-Barre record.
1901, March 28,	18.1 e	137,000	12.2	Estimated from hydrograph.
1901, April 8,	15.5 e	102,000	9.1	Estimated from hydrograph.
1901, April 23,	15.7 e	105,000	9.4	Estimated from hydrograph.
1901, May 31,	15.2 e	98,800	8.8	Estimated from hydrograph.
1901, December 16,	22.8 e	227,000	20.3	
1902, March 3,	26.8 e	.....	.....	Ice gorged.
1902, March 18,	16.9	120,000	10.7	
1902, December 23,	15.3 e	99,900	8.9	Estimated from hydrograph.
1903, January 30,	18.0 e	.....	.....	Ice gorged.
1903, February 6,	15.8 e	.....	.....	Ice gorged.
1903, March 2,	17.8 e	133,000	11.9	Estimated from hydrograph.
1903, March 12,	15.6 e	104,000	9.3	Estimated from hydrograph.
1903, March 25,	18.4 e	142,000	12.7	Estimated from hydrograph.
1903, August 31,	15.5 e	102,000	9.1	Estimated from hydrograph.
1903, October 12,	17.1 e	123,000	11.0	Estimated from hydrograph.
1904, January 25,	25.9 e	.....	.....	Ice gorged.
1904, February 10,	24.5 e	.....	.....	Ice gorged.
1904, March 9,	30.7 e	.....	.....	Ice gorged. Height determined from high water mark on Danville Waterworks Station. Bridge went out 4 p. m.
1904, March 27,	19.6 e	160,000	14.3	Estimated from hydrograph.
1905, March 26,	18.6 e	145,000	12.9	
1906, April 1,	14.6 e	91,800	8.2	
WATER SUPPLY COMMISSION RECORD.				
1907, December 12,	15.6 e	104,000	9.3	
1907, December 25,	14.9 e	95,300	8.5	
1908, February 17,	17.2 e	124,000	11.1	
1908, March 16,	16.9 e	120,000	10.7	

West Branch Susquehanna River Flood of June 1, 1889, at Market Square, Williamsport

TABLE No. 6—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
WATER SUPPLY COMMISSION RECORD—Continued.	Feet.	Second-feet.	Second-feet.	
1908, March 30,	15.8 e	106,000	9.5	Estimated from hydrograph.
1909, February 22,	14.6 e	91,800	8.2	Estimated from hydrograph.
1909, February 26,	14.6 e	91,800	8.2	Estimated from hydrograph.
1909, May 2,	18.2 e	139,000	12.4	Estimated from hydrograph.
1910, March 3,	21.0 e	183,000	16.3	Estimated from hydrograph.
1910, April 26,	17.2 e	124,000	11.1	Estimated from hydrograph.
1911, March 29,	15.2 e	98,800	8.8	Estimated from hydrograph.
1912, March 31,	17.4 e	127,000	11.3	Estimated from hydrograph.
1912, April 3,	18.1 e	137,000	12.2	Estimated from hydrograph.
1913, January 10,	15.9 e	107,000	9.6	Estimated from hydrograph.
1913, March 28,	23.1 e	218,000	19.5	
1914, March 29,	22.7 e	211,000	18.8	Estimated from hydrograph.
1914, April 10,	16.8 e	119,000	10.6	Estimated from hydrograph.
1914, May 14,	17.0 e	122,000	10.9	Estimated from hydrograph.

West Branch Susquehanna River at Williamsport

A daily gage record was started by Mr. George D. Snyder, former City Engineer of Williamsport, on March 1, 1895, the gage being located on the upstream side of the Market Street Bridge and the record to date has been kept by the United States Weather Bureau. A new gage was established by the United States Geological Survey on August 16, 1901, and made to correspond with the old gage, the datum being 496.4 feet above sea level. Since August 24, 1913, two readings daily have been taken by the Water Supply Commission. At a stage of 24 feet the streets of Williamsport are inundated, and the rating curve from which the discharges were taken is not well defined above a gage height of 22 feet. The minimum annual flood stage is 11.5 feet.

TABLE No. 7. *Record of High Water on West Branch Susquehanna River at Williamsport (Drainage Area, 5,670 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1692,				
1731, February 12,				
1733, February 17,				
1737, June 28,				Said to have been 3 feet higher than flood of 1733.
1744,				
1758,				
1762, January 7,				
1772,				
1784, March 15,				
1786, October 5,				
1787, October 1,				
1800, April,				
1804, April 23,				
1810, November 20,	17.5	104,000	18.3	Lancaster Examiner, October 20, 1847, states height was 2.5 feet lower than on October 9, 1847.
1814, August,				
1824, July 20,				Was considered at that time to have been the highest flood on record.
1829, June 28,				
1831, March 5,				
1832, July 4,				
1834, March 17,				
1837, February 12,				
1846, March 13,	24 e	178,000	31	
1847, October 9,	20 e	130,000	23	
1850, July 19,				
1851, July 16,	22 e	152,000	27	
1853, February 7,				
1861, September 28,	24 e	178,000	31	
1865, March 17,	26 e	210,000	37	
1886, January 6,	23 e	164,000	29	
1889, June 1,	32.4 e	350,000	61.7	
1891, February 18,	22.0 e	152,000	26.8	
1894, May 21,	30.0 e	294,000	51.9	
UNITED STATES WEATHER BUREAU RECORD.				
1895, April 10,	12.0	52,400	9.2	
1896, March 31,	14.4 e	72,700	12.8	Estimated from hydrograph.
1897, March 25,	11.9 e	51,600	9.1	Estimated from hydrograph.
1898, March 24,	21.0 e	141,000	24.9	Estimated from hydrograph.
1899, March 5,	13.5 e	64,600	11.4	Estimated from hydrograph.
1900, January 21-22,	13.0			Ice gorged.
1900, November 27,	17.0 e	98,600	17.4	
1901, April 8,	11.5	48,800	8.6	
1901, April 22,	15.9 e	87,400	15.4	Estimated from hydrograph.
1901, May 30,	14.0	69,100	12.2	
1901, December 15,	20.7 e	138,000	24.3	Estimated from hydrograph.
1902, March 1,	21.7 e			Ice gorged.
1902, March 17,	13.8	67,300	11.9	
1902, April 10,	16.6	94,500	16.7	
1903, February 4,	16.0 e	88,400	15.6	
1903, March 1,	17.7 e	106,000	18.7	Estimated from hydrograph.
1903, March 10,	13.2 e	62,000	10.9	
1903, March 24,	13.3	62,800	11.1	
1903, April 16,	11.7	50,200	8.9	
1903, November 18,	12.0	52,400	9.2	
1904, January 23,	16.0 e			Ice gorged.
1904, March 4,	21.0 e	141,000	24.9	Estimated from hydrograph.
1904, March 8,	18.0 e	109,000	19.2	Estimated from hydrograph.
1904, March 24,	18.0	109,000	19.2	
1904, April 2,	17.2 e	101,000	17.8	Estimated from hydrograph.
1905, March 20,	19.4 e	124,000	21.9	Estimated from hydrograph.
1905, December 4,	16.8 e	96,600	17.0	Estimated from hydrograph.
1906, January 24,	11.5 e	48,800	8.6	Estimated from hydrograph.
1907, January 21,	11.5 e	48,800	8.6	Estimated from hydrograph.
1907, March 15,	16.9 e	97,600	17.2	Estimated from hydrograph.
1908, February 16,	17.0 e	98,600	17.4	
1908, March 20,	17.4 e	103,000	18.2	
1908, March 30,	12.4	55,400	9.8	

Frankstown Branch Juniata River Flood of June 1, 1889, showing Fourth Street Bridge, Huntingdon

TABLE No. 7—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
UNITED STATES WEATHER BUREAU RECORD—Continued.				
1909, February 17,	12.0	52,400	9.2	
1909, February 25,	14.5 c	73,600	13.0	
1909, April 15,	12.8 c	58,600	10.3	Estimated from hydrograph.
1909, May 1,	21.0 c	141,000	24.9	
1910, January 22,	12.5 c	56,200	9.9	
1910, March 1,	16.4 c	92,500	16.3	
1910, April 26,	17.3 c	102,000	18.0	
1911, January 15,	19.0 c	120,000	21.2	
1911, October 3,	16.0 c	88,400	15.6	Estimated from hydrograph.
1912, March 16,	18.4 c	113,000	19.9	
1912, March 30,	16.6 c	94,500	16.7	Estimated from hydrograph.
1912, April 3,	17.9 c	108,000	19.0	Estimated from hydrograph.
1912, May 18,	11.6 c	49,400	8.7	Estimated from hydrograph.
1913, January 9,	17.4 c	103,000	18.2	
1913, March 27,	20.4 c	135,000	23.8	
1913, April 29,	12.0 c	52,400	9.2	
1913, May 29,	12.4 c	55,400	9.8	
WATER SUPPLY COMMISSION RECORD.				
1914, March 29,	19.2 c	122,000	21.5	

Frankstown Branch Juniata River at Huntingdon

Regular gage readings were started May 1, 1895, by the United States Weather Bureau, using a gage on the pier of the Fourth Street Bridge, which record has been utilized in the preparation of Table No. 8. The zero of the gage is 595.12 feet above sea level. The drainage area of 845 square miles does not include that of Crooked Creek which empties into the Frankstown Branch Juniata River a short distance below the gage. The rating curve from which the discharges in Table No. 8 were calculated is not well defined above a gage height of 14 feet. The minimum annual flood stage is 7.9 feet.

TABLE No. 8. *Record of High Water on Frankstown Branch Juniata River at Huntingdon (Drainage Area, 845 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1810, November 20,	18.5	73,500	87.0	
1838, June 19,	.....	.....	.....	
1843, April 11,	.....	.....	.....	According to Williamsburg Banner of April 11, 1843, was same height as 1838 flood.
1847, October 8,	.....	.....	.....	
1851, July 16,	.....	.....	.....	Approximately same height as in 1847.
1870, April 3,	.....	.....	.....	Two lives lost at Huntingdon.
1889, June 1,	22.5 e	106,000	125.4	Determined from high water marks.
UNITED STATES WEATHER BUREAU RECORD.				
				No record from September 1, 1893, to April 30, 1895.
1894, May 21,	17.2 e	63,000	74.6	Height was 5 feet 4 inches lower than 1889 mark, according to Huntingdon Semi-Weekly News of May 24, 1894.
1896, September 30,	11.5	21,000	24.9	
1897, February 23,	8.7	10,800	12.8	
1898, March 23,	10.2	15,400	18.2	
1898, May 24,	8.0	8,900	10.5	
1898, October 22,	9.7	13,700	16.2	
1899, March 30,	.....	.....	.....	
				No record from January 8th to 14th inclusive; January 28th to February 20th inclusive; March 10th to June 2d inclusive, 1899.
1900, January 21,	8.0	8,900	10.5	
1900, November 26,	8.5	10,200	12.1	
1901, March 11,	9.8	14,100	16.7	
1901, April 21,	8.5	10,200	12.1	
1901, December 15,	14.0	37,800	44.7	
1902, March 1,	13.0	30,000	35.5	
1902, April 9,	12.0	23,500	27.8	
1903, February 4,	11.0 e	18,600	22.0	
1903, February 28,	8.9	11,300	13.4	
1903, March 24,	8.4	9,920	11.7	
1903, August 28,	8.9 e	11,300	13.4	
1904, February 8,	9.0	11,600	13.7	
1904, March 8,	8.2	9,400	11.1	
1904, April 2,	8.5	10,200	12.1	
1905, March 21,	9.7 e	13,700	16.2	
1906, March 31,	7.9	8,650	10.2	
1907, March 14,	13.3 e	32,200	38.1	Estimated from hydrograph.
1908, January 13,	8.0	8,900	10.5	
1908, February 16,	8.7	10,800	12.8	
1908, March 19,	13.6	34,600	40.9	
1908, May 22,	10.0	14,800	17.5	
1909, February 24,	9.0	11,600	13.7	
1910, January 22,	9.7	13,700	16.2	
1910, March 1-3,	9.1	11,900	14.1	
1911, January 14,	8.8 e	11,000	13.0	
1911, September 15,	9.3 e	12,500	14.8	
1911, October 2,	8.7	10,800	12.8	
1912, February 27,	8.2	9,400	11.1	
1912, March 15,	8.7	10,800	12.8	
1912, March 29,	8.4	9,920	11.7	
1912, May 16,	9.2 e	12,200	14.4	
1913, March 27,	8.3 e	9,660	11.4	
1913, May 28,	9.8 e	14,100	16.7	
1913, October 26,	8.2	9,400	11.1	
1914, March 28,	8.3 e	9,660	11.4	

Juniata River at Newport

The record was started by the United States Geological Survey on March 21, 1899, the gage being fastened to the highway bridge. The zero of the gage is 363.32 feet above sea level. For the years 1896 to 1899, inclusive, an approximate record was derived from the Weather Bureau gage readings at Mifflin, by establishing a relation between the two gages. The discharges in Table No. 9 have been obtained by the use of two rating tables, the first being applicable to December 31, 1911, inclusive, and the second subsequent thereto. Both tables were computed from rating curves which are well defined below a gage height of 20 feet. The minimum annual flood stage is 10.7 feet.

TABLE No. 9. *Record of High Water on Juniata River at Newport (Drainage Area, 3,380 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1802, Spring,	.....	.....	.....	
1810, November 20,	28 c	131,000	39	At Lewistown was nearly as high as 1847 flood.
1837, March,	.....	.....	.....	Ice gorged.
1840, February,	.....	.....	.....	Ice gorged.
1843, September 20,	.....	.....	.....	Higher than in 1846.
1846, March 13,	20 c	79,200	23	At Lewistown same height as 1837 flood and 5 to 10 feet less than in 1847.
1847, October 9,	28.5 c	134,000	39.6	The News of Newport, June 7, 1889, gives height as 7.0 to 7.5 feet lower than in 1889.
1851, July 16,	.....	.....	.....	
1857, February 8,	.....	.....	.....	Ice gorged.
1861, November 3,	.....	.....	.....	
1865, March 18,	.....	.....	.....	At Lewistown was 7 feet lower than 1847 flood.
1874, December 29,	.....	.....	.....	
1875, February 26,	.....	.....	.....	Ice gorged.
1876, June 18,	.....	.....	.....	
1881, February 11,	.....	.....	.....	Ice gorged.
1886, January,	.....	.....	.....	At Lewistown same height as 1865 flood.
1889, June 1,	35.9 c	182,000	53.8	Determined from high water marks.
1894, May 21,	31.0 c	151,000	44.7	
ESTIMATED FROM WEATHER BUREAU RECORD, MIFFLIN GAGE.				
1896, March 31,	11	28,100	8	
1896, October 1,	15.5	51,000	15	
1896, November 6,	11	28,100	8	
1897, February 23,	13	37,400	11	
1897, April 10,	11	28,100	8	
1897, May 3,	12	32,600	10.0	
1898, March 23,	13	37,400	11	
1898, October 24,	13	37,400	11	
1899, February 23,	12	.....	.....	Ice gorged.
1899, March 6,	11	28,100	8	

TABLE No. 9—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
UNITED STATES GEOLOGICAL SURVEY RECORD.				
1900, January 21,	11.8 e	31,800	9.4	Estimated from hydrograph.
1900, February 22,	11.7	31,300	9.3	
1900, March 2,	12.9	36,900	10.9	
1900, November 27,	11.6	30,800	9.1	
1901, March 11,	15.9	53,300	15.8	
1901, April 7,	11.0	28,100	8.3	
1901, April 22,	13.8	41,400	12.2	
1901, May 30,	13.3	38,800	11.5	
1901, December 15,	22.0 e	92,200	27.3	Estimated from hydrograph.
1902, March 1,	25.3 e	114,000	33.7	
1902, March 17,	15.3	49,800	14.7	
1902, April 9-10,	18.5	69,400	20.5	
1902, December 23,	10.8	27,200	8.0	
1903, February 5,	14.5	45,200	13.4	
1903, March 1,	15.5	51,000	15.1	
1903, March 24,	12.7	36,000	10.7	
1903, April 16,	15.6	51,600	15.3	
1904, January 24,	11.0	.....	.....	Ice gorged.
1904, February 7,	11.5	30,400	9.0	
1904, March 4,	13.5	39,800	11.8	
1904, March 8,	14.0	42,400	12.5	
1904, April 2,	13.4	39,300	11.6	
1905, March 11,	12.2	33,600	9.9	
1905, March 22,	16.0 e	53,800	15.9	Estimated from hydrograph.
1906, March 31,	11.0	28,100	8.3	
				No record for period July 14, 1906, to January 7, 1907.
1907, January 15,	11.4	29,900	8.8	
1907, March 15,	23.5 e	102,000	30.2	Estimated from hydrograph.
WATER SUPPLY COMMISSION RECORD.				
1908, January 14,	11.4	29,900	8.8	
1908, February 16,	13.9	41,900	12.4	
1908, March 20,	21.3 e	87,600	25.9	Estimated from hydrograph.
1908, May 8,	12.8	36,400	10.8	
1908, May 20,	15.9 e	53,300	15.8	Estimated from hydrograph.
1909, February 25,	12.4 e	34,600	10.2	Estimated from hydrograph.
1909, April 15,	11.3 e	29,400	8.7	Estimated from hydrograph.
1910, January 22,	17.4 e	.....	.....	Ice gorged.
1910, March 2,	13.4	39,300	11.6	
1910, April 26,	13.0	37,400	11.1	
1911, January 15,	10.7 e	.....	.....	Ice gorged.
				Second rating table.
1912, February 27,	11.6	.....	.....	Ice gorged.
1912, March 16,	13.8 e	42,200	12.5	
1912, March 30,	12.1	33,600	9.9	
1912, May 17,	11.4 e	30,300	9.0	
1913, March 28,	12.9 e	37,500	11.1	Estimated from hydrograph.
1913, May 29,	16.7 e	58,600	17.3	
1914, February 1,	13.8 e	42,200	12.5	
1914, March 18,	13.1 e	38,500	11.4	Ice gorged.
1914, March 29,	12.0 e	33,100	9.8	

Susquehanna River at Harrisburg

The first daily gage readings were taken by Mr. William A. Kelker during the period January 1, 1874, to December 31, 1893, at the gage on the old Market Street Bridge. During the period 1890 to 1904 a similar record was kept at the Harrisburg Pumping Station under the direction of Mr. E. Mather. On July 18, 1904, a gage was estab-

lished by the United States Geological Survey on the upstream side of the Walnut Street Bridge, and by establishing a relation between the gages it has been possible to refer all records here published to that gage, the datum of which is 289.4 feet above sea level. Since the establishment of the Geological Survey gage, readings have been taken by the United States Weather Bureau, whose record has been utilized in the preparation of Table No. 10 for the period 1905 to 1910, inclusive. Gage readings taken under the direction of the Pennsylvania Water & Power Company during 1911, 1912 and 1913 were utilized for those years, and since 1914 the record kept by the Water Supply Commission has been used. All discharges in Table No. 10 are referred to a rating curve which is well defined below a gage height of 20 feet. The minimum annual flood stage is 10.9 feet.

TABLE No. 10. *Record of High Water on Susquehanna River at Harrisburg (Drainage Area, 24,100 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
EARLY FLOODS.	Feet.	Second-feet.	Second-feet.	All data approximate.
1740,	.....	.....	.....	Hazard's Register, Volume IX, page 104, states height exceeded that of 1784.
1744,	.....	.....	.....	Article by Mr. Garrecht in Lancaster Examiner, February 9, 1832.
1758,	.....	.....	.....	Article by Mr. Garrecht in Lancaster Examiner, February 9, 1832.
1772,	.....	.....	.....	Article by Mr. Garrecht in Lancaster Examiner, February 9, 1832.
1784, March 15,	22–25	.....	.....	Ice gorged.
1786, October 5,	22 c	494,000	20	
1809, April,	.....	.....	.....	
1810, November 20,	.....	.....	.....	
1814, August,	.....	.....	.....	
1817, August,	.....	.....	.....	
1832, February 6,	.....	.....	.....	Ice gorged.
1833, May 15,	18 c	357,000	15	Dr. John Heisely's record gives 17 feet above low water.
1837, March,	.....	.....	.....	Ice gorged.
1841, January 6-10,	.....	.....	.....	Ice gorged.
1843, April 26,	.....	.....	.....	
1846, March 15,	22 c	494,000	20	Dr. John Heisely's record gives 20 feet 8 inches above low water. Deputy Sheriff Shell's record gives 20 feet 4 inches.
1846, March 26,	16 c	297,000	12	Dr. John Heisely's record gives 15 feet above low water. Harrisburg Telegraph of March 28, 1846, gives height as being within one foot of 1833 flood.
1847, October 9,	18 c	357,000	15	Dr. John Heisely's record gives 16 feet 8 inches above low water.
1850, July 20,	.....	.....	.....	
1853, February 7,	18 c	357,000	15	From Borough Item of Harrisburg, February 8, 1853.
1865, March 18,	24.6 c	602,000	25.0	Dr. John Heisely's record quoted as giving 23.5 feet.
1868, March 19,	20.0 c	422,000	17.5	

TABLE No. 10—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
WILLIAM A. KELKER'S RECORD.				
1874, January 9,	11.1 e	170,000	7.1	
1874, April 22,	11.3 e	175,000	7.3	
1875, March 2,	14.1 e	.....	.....	Ice gorged.
1875, March 18,	15.6 e	.....	.....	Ice gorged.
1875, April 4,	18.0 e	.....	.....	Ice gorged.
1876, April 16,	11.9 e	189,000	7.8	
1876, June 19,	12.3 e	199,000	8.3	
1877, March 11,	13.1 e	219,000	9.1	
1877, March 29,	13.6 e	232,000	9.6	
1878, February 25,	13.6 e	232,000	9.6	
1878, March 14-15,	11.1 e	170,000	7.1	
1878, December 12,	19.9 e	419,000	17.4	
1879, March 13,	14.1 e	245,000	10.2	
1880, February 15,	10.9 e	166,000	6.9	
1881, February 13,	19.4 e	.....	.....	Ice gorged.
1881, March 21,	12.6 e	206,000	8.5	
1881, June 11,	13.6 e	232,000	9.6	
1881, December 29,	12.6 e	206,000	8.5	
1882, February 23,	13.3 e	224,000	9.3	
1882, March 3,	13.6 e	232,000	9.6	
1883, June 28,	12.6 e	206,000	8.5	
1884, February 8,	15.6 e	286,000	11.9	
1884, February 15,	17.2 e	332,000	13.8	
1884, March 14,	11.6 e	182,000	7.6	
1885, April 5,	13.9 e	.....	.....	Ice gorged.
1886, January 6,	19.0 e	389,000	16.1	
1886, February 13,	20.8 e	.....	.....	Ice gorged
1886, April 2,	16.1 e	300,000	12.4	
1886, April 8,	16.1 e	300,000	12.4	
1886, November 20,	11.6 e	182,000	7.6	
1887, January 26,	11.1 e	170,000	7.1	
1887, February 13,	12.6 e	206,000	8.5	
1888, February 24,	11.3 e	175,000	7.3	
1888, March 23,	11.5 e	179,000	7.4	
1888, March 31,	11.6 e	182,000	7.6	
1888, April 7,	12.3 e	199,000	8.3	
1888, December 19,	13.1 e	219,000	9.1	
1889, June 2,	26.8 e	707,000	29.3	
1889, November 21,	15.1 e	272,000	11.3	
1890, March 24,	11.3 e	175,000	7.3	
1890, April 10,	11.3 e	175,000	7.3	
1890, May 22,	12.1 e	194,000	8.0	
1890, October 26,	13.3 e	224,000	9.3	
E. MATHER'S RECORD.				
1891, February 2,	11.3 e	175,000	7.3	
1891, February 19,	19.7 e	412,000	17.1	Estimated from hydrograph.
1891, February 28,	12.9 e	214,000	8.9	
1892, January 15,	14.0 e	242,000	10.0	Estimated from hydrograph.
1892, March 29,	13.0 e	216,000	9.0	Estimated from hydrograph.
1892, April 5,	15.0 e	269,000	11.2	Estimated from hydrograph.
1892, June 5,	12.3 e	199,000	8.3	
1893, February 12,	11.5 e	179,000	7.4	Estimated from hydrograph.
1893, March 11,	14.8 e	264,000	11.0	Estimated from hydrograph.
1893, March 13,	15.0 e	269,000	11.2	Estimated from hydrograph.
1893, April 23,	11.0 e	168,000	7.0	Estimated from hydrograph.
1893, May 6,	16.9 e	324,000	13.4	Estimated from hydrograph.
1894, March 9,	12.0	191,000	7.9	
1894, May 22,	25.4 e	639,000	26.5	
1895, April 11,	13.5	229,000	9.5	
1896, February 8,	12.3	199,000	8.3	
1896, April 1,	14.8 e	264,000	11.0	Estimated from hydrograph.
1897, March 26,	11.5 e	179,000	7.4	Estimated from hydrograph.
1898, March 24,	16.6 e	315,000	13.1	Estimated from hydrograph.
1899, March 6,	13.4 e	227,000	9.4	Estimated from hydrograph.
1900, January 23,	11.8	187,000	7.8	
1900, March 2,	12.9	214,000	8.9	
1900, November 28,	14.2 e	248,000	10.3	Estimated from hydrograph
1901, March 13,	11.6	182,000	7.6	
1901, March 29,	12.7	203,000	8.7	
1901, April 9,	12.6	206,000	8.5	
1901, April 23,	13.4	227,000	9.4	

Allegheny River Flood of March 27, 1913, at Warren

TABLE No. 10—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
E. MATHER'S RECORD—Continued.				
1901, May 31,	13.7	235,000	9.8	
1901, December 16,	21.2 c	464,000	19.3	
1902, March 2,	23.7 c	564,000	23.4	
1902, March 18,	14.8	264,000	11.0	
1902, April 10,	14.5	256,000	10.6	
1902, December 24,	12.5	204,000	8.5	
1903, February 6,	14.4	253,000	10.5	
1903, March 2,	16.6 c	315,000	13.1	
1903, March 25,	15.0	269,000	11.2	
1903, April 17,	12.6	206,000	8.5	
1903, October 12,	11.1	170,000	7.1	
1904, January 24,	15.3	.....	.....	Ice gorged.
1904, February 14,	13.3	.....	.....	Ice gorged.
1904, March 4,	23.3	.....	.....	Ice gorged.
1904, March 8,	22.3	.....	.....	Ice gorged.
1904, March 27,	15.1 c	272,000	11.3	
1904, April 3,	12.9	214,000	8.9	
UNITED STATES WEATHER BUREAU RECORD.				
1905, March 21,	15.9 c	295,000	12.2	Estimated from hydrograph.
1905, December 5,	12.2	196,000	8.1	
1906, April 16,	11.2	172,000	7.1	
1907, March 16,	13.3 c	224,000	9.3	
1908, February 17,	15.0 c	269,000	11.2	
1908, March 20,	16.0 c	297,000	12.3	
1909, February 26,	13.0 c	216,000	9.0	
1909, April 16,	11.2 c	172,000	7.1	
1909, May 2,	16.0 c	297,000	12.3	
1910, January 22,	13.0 c	216,000	9.0	
1910, March 3,	17.2 c	332,000	13.8	
1910, April 26,	15.8 c	292,000	12.1	
PENNSYLVANIA WATER & POWER COMPANY RECORD.				
1911, January 16,	11.5 c	179,000	7.4	
1912, March 30,	13.9 c	240,000	10.0	
1912, April 4,	14.3 c	250,000	10.4	
1913, January 10,	13.2 c	222,000	9.2	
1913, March 28,	19.5 c	406,000	16.8	
WATER SUPPLY COMMISSION RECORD.				
1914, February 1,	12.6 c	206,000	8.5	
1914, March 29,	18.5 c	373,000	15.5	
1914, April 10,	11.8 c	187,000	7.8	
1914, May 15,	12.9 c	214,000	8.9	

Allegheny River at Warren

The flood record is derived mainly from the river stage observations made by the United States Weather Bureau, on the gage at the Suspension Bridge established by the United States Engineers in November 1884. The zero of the gage is 1,170.66 feet above sea level. Discharges are not available as no current meter measurements are made at this point. The minimum annual flood stage is 7.2 feet.

TABLE No. 11. *Record of High Water on Allegheny River at Warren*

Date.	Gage Height.	Notes.
	Feet.	
EARLY FLOODS.		All data approximate.
1806, April,	.....	
1810, November 10,	.....	
1828, January,	.....	
1832, February 9,	.....	
1835, October 21,	.....	
1840, February 1,	.....	
1852, April 19,	.....	
1865, March 17,	17.4 c	Determined from high water marks.
1867, February 12,	.....	Ice gorged.
1873, January 17,	.....	Ice gorged.
1873, December 13,	15.7 c	Determined from high water marks.
1875, March 15,	.....	Ice gorged.
UNITED STATES WEATHER BUREAU RECORD.		
1885, April 9,	7.5	
1885, August 26,	9.2 c	Estimated from hydrograph.
1886, January 5,	8.3	
1886, February 14,	7.4	
1886, March 22,	7.4	
1886, April 2,	7.4	
1886, November 24,	7.8	
1887, January 24,	8.0	
1887, February 9,	11.0	
1887, February 12,	11.9	
1888, April 6,	9.3	No record for July, August or September, 1888.
1889, June 3,	11.7	Record for June 1889 incomplete.
1890, April 10,	7.4	
1890, May 21,	9.1	
1890, May 26,	8.2	
1890, September 13,	11.3	
1891, February 18,	12.0	
1892, April 5,	7.9	
1892, May 7,	9.0	
1892, June 5,	8.2	
1893, March 12,	8.1	
1893, March 25,	8.2	
1893, April 9,	7.9	
1893, May 17,	8.0	
1893, December 17,	9.2	
1894, March 7,	8.5	
1894, May 22,	13.8	
1895, March 2,	7.5	
1895, April 10,	9.3	
1895, December 28,	7.2	
1896, March 31,	11.2 c	Estimated from hydrograph.
1897, March 11,	8.6	
1898, January 13,	7.6	
1898, February 13,	8.2	
1898, March 24,	7.6	
1898, November 11,	8.0	
1899, December 20,	7.2	
1900, January 21,	9.3	
1900, November 27,	9.5 c	
1901, March 12,	8.0	
1901, March 27,	10.8	
1901, April 24,	10.1 c	Estimated from hydrograph.
1901, December 15,	10.9	
1902, March 2,	13.5	
1902, March 14,	7.9	
1902, April 10,	7.3	
1902, July 21,	7.4	
1903, February 5,	10.1	
1903, March 1,	9.8	
1903, March 9,	9.7	
1904, January 23,	10.2	
1904, February 8,	11.4	
1904, March 8,	11.1	
1904, March 27,	11.4	
1904, April 3,	7.5	
1904, December 29,	7.8	
1905, March 20,	13.5	
1906, March 28,	7.3	
1906, December 7,	7.4	
1907, January 9,	7.2	
1907, March 28,	7.2	
1907, December 24,	7.8 c	
1908, February 15,	12.2 c	
1908, March 16,	10.0	
1909, January 6,	7.5 c	
1909, January 25,	7.2 c	Estimated from hydrograph.
1909, February 25,	9.0	

TABLE No. 11—Continued

Date.	Gage Height.	Notes.
	Feet.	
UNITED STATES WEATHER BUREAU RECORD—Continued.		
1909, May 2,	12.5	
1910, March 4,	11.8	
1910, March 7,	11.5	
1910, April 26,	7.2 c	Estimated from hydrograph.
1911, January 4,	8.0	
1911, January 15,	9.0	
1911, January 28,	9.0 c	
1911, February 18,	7.4	
1911, August 29,	8.7	
1912, March 20,	9.8	
1912, April 2,	12.9 c	
1912, April 8,	10.0	
1913, January 8,	11.1 c	
1913, January 19,	8.8	
1913, March 27,	15.2 c	
1913, April 29,	8.9	
1914, January 30-February 1,	8.0	
1914, March 28,	13.4 c	
1914, May 13,	10.0 c	

Allegheny River at Kittanning

The record in Table No. 12 is referred to the gage established August 18, 1904, by the United States Geological Survey. Since April 1907 the station has been maintained by the Water Supply Commission. For the period January 1, 1885, to August 18, 1904, the gage heights have been derived from Weather Bureau gage readings taken on the Allegheny River at Parker, and are only approximate. In some instances flood heights were computed by reference to the record obtained at Freeport, account being taken of intervening tributaries. All discharges are referred to a rating curve which is well defined to the maximum gage height appearing in Table No. 12. The minimum annual flood stage is 15.0 feet.

TABLE No. 12. *Record of High Water on Allegheny River at Kittanning (Drainage Area, 9,010 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1806, April 10,	30	259,000	29	
1810, November 10,	.....	.....	.....	
1828, January,	.....	.....	.....	
1832, February 9,	29	.....	.....	Ice gorged. Claimed to have exceeded 1865 record.
1835, July 16,	.....	.....	.....	Hazard's Register.
1836,	.....	.....	.....	Ice gorged.
1840, February 1,	.....	.....	.....	
1852, April 19,	.....	.....	.....	Higher than flood of 1832.
1865, March 18,	29.5 c	252,000	28.0	Determined from high water marks.
1873, December 13,	27 c	217,000	24	Estimated.
1881, June 10,	28 c	231,000	26	Estimated from Freeport record.
1883, February 5,	29 c	245,000	27	Estimated from Freeport record.
1884, February 6,	28 c	231,000	26	Estimated from Freeport record.
ESTIMATED FROM WEATHER BUREAU RECORD—PARKER GAGE.				
				No record from January 23d to March 30, 1885.
1885, April 4,	17.1	97,600	10.8	Estimated from Freeport record.
1885, April 9,	15.4	81,500	9.0	Estimated from Freeport record.
1886, January 6,	17.6	103,000	11.4	
1886, February 13,	26.6	.....	.....	Ice gorged.
1886, March 22,	16.0	87,000	9.7	Estimated from Freeport record.
1886, April 2,	16.0	87,000	9.7	
1886, April 7,	16.2	88,900	9.9	
1886, November 19,	15.4	81,500	9.0	Estimated from Freeport record.
1886, November 24-25,	15.4	81,500	9.0	
1887, January 25,	17.1	97,600	10.8	
1887, February 9,	20.4	133,000	14.8	
1887, February 12,	23.8	174,000	19.3	
1888, February 26,	15.0	77,900	8.6	
1888, April 7,	17.5	102,000	11.3	
				No record from July to October, inclusive, 1888.
1889, June 2,	16.2	88,900	9.9	
1890, January 7,	15.0	77,900	8.6	
1890, February 27,	15.4	81,500	9.0	
1890, April 10,	15.6	83,300	9.2	
1890, May 11,	16.0	87,000	9.7	
1890, May 21,	16.8	94,600	10.5	Estimated from Freeport record.
1890, May 24,	24.2	179,000	19.9	
1890, September 13,	17.1	97,600	10.8	Estimated from Freeport record.
1891, February 18,	26.6	211,000	23.4	Estimated from Freeport record.
1892, March 28,	16.0	87,000	9.7	
1892, May 5,	15.0	77,900	8.6	Estimated from Freeport record.
1892, June 6,	19.3	121,000	13.4	Estimated from Freeport record.
1893, February 7,	20.4	133,000	14.8	
1893, February 11,	18.2	109,000	12.1	
1893, February 16,	15.0	77,900	8.6	
1893, March 13,	17.7	104,000	11.5	
1893, April 22,	15.5	82,400	9.1	
1893, May 18,	21.4	145,000	16.1	
1893, December 17,	18.2	109,000	12.1	
1894, May 21,	23.2	167,000	18.5	
1895, January 27 to February 3,	15.0	77,900	8.6	
1895, March 3,	24.2	.....	.....	Ice gorged.
1895, April 10,	18.2	109,000	12.1	
1895, April 14,	15.0	77,900	8.6	Estimated from Freeport record.
1895, December 28,	16.0	87,000	9.7	
1896, March 31,	18.2	109,000	12.1	
1897, March 7,	17.8	105,000	11.7	
1897, March 11,	17.1	97,600	10.8	
1898, January 14,	16.0	87,000	9.7	
1898, January 24,	15.0	77,900	8.6	
1898, February 13,	18.4	111,000	12.3	
1898, March 20,	15.0	77,900	8.6	
1898, March 24,	20.6 c	136,000	15.1	Estimated from hydrograph.
1898, November 12,	15.0	77,900	8.6	
1899, December 20,	15.3	80,600	8 9	
1900, January 22,	16.0	87,000	9.7	
1900, March 7,	15.0	77,900	8.6	

TABLE No. 12—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
ESTIMATED FROM WEATHER BUREAU RECORD—PARKER GAGE—Continued.				
1900, November 27,	17.7 e	104,000	11.5	Estimated from hydrograph.
1901, March 12,	16.6	92,700	10.3	
1901, March 28,	18.2	109,000	12.1	
1901, April 21,	17.1 e	97,600	10.8	Estimated from hydrograph.
1901, December 15,	17.4 e	101,000	11.2	Estimated from hydrograph.
1902, March 1-2,	25.1 e	191,000	21.2	Estimated from hydrograph.
1902, March 14,	15.1	78,800	8.7	
1902, April 10,	15.2	79,700	8.8	
1902, July 4,	16.4	90,800	10.1	
1903, January 30,	16.4	90,800	10.1	Estimated from Freeport record.
1903, February 5,	17.3	99,600	11.1	
1903, March 1,	20.4	133,000	14.8	
1903, March 9,	18.2	109,000	12.1	
1903, March 12,	18.4	111,000	12.3	
1903, November 18,	15.0	77,900	8.6	
1904, January 23,	24.2	179,000	19.9	
1904, February 8,	19.8	127,000	14.1	
1904, March 4,	21.2	143,000	15.9	
1904, March 8,	20.2	131,000	14.5	
1904, March 27,	18.7	114,000	12.7	Estimated from Freeport record.
1904, April 2,	19.5 e	123,000	13.7	Estimated from hydrograph.
UNITED STATES GEOLOGICAL SURVEY RECORD.				
1905, January 16,	16.3 e	89,800	10.0	Estimated from hydrograph.
1905, March 20,	29.0 e	245,000	27.2	Estimated from hydrograph.
1905, December 3,	16.0 e	87,000	9.7	Estimated from hydrograph.
1906, March 28,	15.0 e	77,900	8.6	Estimated from hydrograph.
1907, March 15,	18.0 e	107,000	11.9	Estimated from hydrograph.
WATER SUPPLY COMMISSION RECORD.				
1907, December 24,	16.2 e	88,900	9.9	
1908, February 16,	24.6 e	184,000	20.4	Estimated from hydrograph.
1908, March 7,	16.4	90,800	10.1	
1908, March 19,	19.8 e	127,000	14.1	
1909, January 15,	15.4 e	81,500	9.0	
1909, February 16,	18.2 e	109,000	12.1	Estimated from hydrograph.
1909, February 25,	17.8 e	105,000	11.7	Estimated from hydrograph.
1909, April 30,	23.9	176,000	19.5	
1910, January 19,	15.7 e	84,200	9.3	Estimated from hydrograph.
1910, March 2-3,	21.0 e	140,000	15.5	
1910, March 7,	21.6 e	147,000	16.3	
1910, December 30,	15.0 e	77,900	8.6	
1911, January 15,	19.7 e	125,000	13.9	
1911, January 29,	16.5 e	91,700	10.2	Estimated from hydrograph.
1911, September 15,	15.3 e	80,600	8.9	Estimated from hydrograph.
1911, October 2,	20.0 e	129,000	14.3	Estimated from hydrograph.
1912, February 27,	15.7 e	84,200	9.3	
1912, March 17,	16.4 e	.....	.....	Ice gorged.
1912, March 21,	17.2 e	98,600	10.9	
1912, March 31,	18.7 e	114,000	12.7	Estimated from hydrograph.
1912, April 3,	22.6 e	159,000	17.6	Estimated from hydrograph.
1912, September 3,	17.0 e	96,600	10.7	Estimated from hydrograph.
1913, January 9,	25.3 e	194,000	21.5	
1913, January 12,	18.2 e	109,000	12.1	
1913, January 20,	16.3 e	89,800	10.0	Estimated from hydrograph.
1913, March 26,	30.4 e	265,000	29.4	Determined from high water marks.
1914, January 31,	17.2 e	98,600	10.9	
1914, March 29,	23.1 e	165,000	18.3	
1914, May 13,	19.4 e	122,000	13.5	

Allegheny River at Freeport

The record in Table No. 13 is based on the gage readings taken by the United States Weather Bureau since January 1, 1875. Discharges were computed from gagings made by the United States Geological Survey during 1912 and 1914 which includes the discharge of Buffalo Creek and are subject to correction. The rating curve from which the discharge table was calculated is not well defined above a gage height of 22 feet. The gage was originally fastened to a pier of the railroad bridge at the mouth of Buffalo Creek, but in 1899 it was moved to the County Bridge across the Allegheny River, although its datum, which is 741 feet above sea level, has remained unchanged. The minimum annual flood stage is 16.0 feet.

TABLE No. 13. *Record of High Water on Allegheny River at Freeport (Drainage Area, 11,400 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1806, April 10,	.....	.....	.....	
1810, November 10,	.....	.....	.....	
1832, February 9,	.....	.....	.....	
1840, February 1,	.....	.....	.....	
1852, April 19,	.....	.....	.....	
1865, March 18,	32	292,000	26	Height of 34.4 feet according to Mrs. Burtner; 26 feet according to Mr. Archibald.
1873, December 13,	.....	.....	.....	
1874, January 8,	.....	.....	.....	
UNITED STATES WEATHER BUREAU RECORD.				
1875, March 16,	19.2	117,000	10.3	
1875, April 3,	20.8 e	134,000	11.8	
1875, December 25,	16.2	86,800	7.6	
1875, December 27,	19.6	121,000	10.6	
1876, February 12,	19.0 e	115,000	10.1	
1876, April 14,	16.6	90,400	7.9	
1877, March 10,	20.3 e	129,000	11.3	Estimated from hydrograph.
1877, March 28,	18.0	104,000	9.1	
1878, February 24,	17.0	94,300	8.3	
1878, December 11,	23.0 e	159,000	13.9	
1879, January 29,	18.2	106,000	9.3	
1879, March 12,	22.7	.....	.....	Ice gorged.
1880, February 14,	16.0 e	85,000	7.5	Estimated from hydrograph.
1881, February 13,	20.6	132,000	11.6	
1881, June 10,	29.4 e	250,000	21.9	
1881, November 20,	17.8	102,000	9.0	
1882, January 28,	23.0 e	159,000	13.9	
1882, February 22,	18.3	107,000	9.4	
1883, February 5,	30.5	268,000	23.5	
1883, February 15,	19.2	117,000	10.3	
1883, February 17,	20.0	125,000	11.0	
				No record from June 12th to November 3, 1883.
1884, February 6,	30.0	260,000	22.8	
1884, February 15,	21.8	145,000	12.7	
1884, March 13,	21.0	136,000	11.9	
1884, March 16,	16.5	89,500	7.9	
1885, January 17,	19.2 e	117,000	10.3	Estimated from hydrograph. No record from February 14th to March 30, 1885.

TABLE No. 13—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
UNITED STATES WEATHER BUREAU RECORD—Continued.				
1885, April 5,	18.0 e	104,000	9.1	Estimated from hydrograph.
1885, April 9,	16.0 e	85,000	7.5	Estimated from hydrograph.
1886, January 6,	20.0	125,000	11.0	
1886, February 14,	20.7	133,000	11.7	
1886, March 22,	16.5 e	89,500	7.9	Estimated from hydrograph.
1886, April 2,	16.5	89,500	7.9	
1886, April 7,	18.0	104,000	9.1	
1886, November 19,	16.2 e	86,800	7.6	Estimated from hydrograph.
1886, November 25,	16.6 e	90,400	7.9	Estimated from hydrograph.
1887, January 25,	17.5 e	99,300	8.7	Estimated from hydrograph.
1887, February 9,	22.6 e	154,000	13.5	Estimated from hydrograph.
1887, February 12,	24.6 e	179,000	15.7	Estimated from hydrograph.
				No record from December 23d to 31st, 1887.
1888, January 8,	18.6	110,000	9.6	
1888, April 7,	18.0 e	104,000	9.1	Estimated from hydrograph.
				No record from July 1st to September 30, 1888.
1888, August 21,	.....	.....	.....	
1889, June 1,	19.0	115,000	10.1	
1890, January 16,	16.0	85,000	7.5	
1890, March 23,	16.4 e	88,600	7.8	Estimated from hydrograph.
1890, April 10,	20.0 e	125,000	11.0	
1890, May 21,	17.4 e	98,300	8.6	Estimated from hydrograph.
1890, May 24,	25.1 e	185,000	16.2	Estimated from hydrograph.
1890, September 13,	18.3 e	107,000	9.4	Estimated from hydrograph.
1891, February 18,	32.7 e	303,000	26.6	
1892, March 28,	17.5	99,300	8.7	
1892, June 4,	16.0	85,000	7.5	
1892, June 6,	20.2 e	127,000	11.1	Estimated from hydrograph.
1893, February 8,	22.5	153,000	13.4	
1893, February 11,	22.2	149,000	13.1	
1893, February 16,	16.5	89,500	7.9	
1893, March 13,	18.4	108,000	9.5	
1893, April 22,	16.6	90,400	7.9	
1893, May 18,	22.8 e	157,000	13.8	
1893, December 17,	18.9 e	114,000	10.0	Estimated from hydrograph.
1894, May 22,	25.6 e	192,000	16.8	Estimated from hydrograph.
1895, January 8,	19.0	115,000	10.1	
1895, April 10,	20.6	132,000	11.6	
1895, April 14,	18.3	107,000	9.4	
1896, March 31,	20.2	127,000	11.1	
1897, March 6,	21.1 e	137,000	12.0	Estimated from hydrograph.
1897, March 11,	18.0 e	104,000	9.1	Estimated from hydrograph.
1898, January 14,	18.0	104,000	9.1	
1898, January 24,	16.8	92,300	8.1	
1898, February 13,	16.1	85,900	7.5	
1898, March 23,	28.4 e	234,000	20.5	
1899, March 7,	17.8 e	102,000	9.0	Estimated from hydrograph.
1900, January 22,	17.5	99,300	8.7	
1900, February 9,	16.5	89,500	7.9	
1900, March 7,	16.0	85,000	7.5	
1900, November 27,	21.7 e	144,000	12.6	
1901, March 12,	17.9	103,000	9.0	
1901, March 28,	19.0 e	115,000	10.1	Estimated from hydrograph.
1901, April 7,	18.0	104,000	9.1	
1901, April 21,	23.0 e	159,000	13.9	
1901, December 16,	21.4	140,000	12.3	
1902, March 1,	30.0 e	260,000	22.8	
1902, March 15,	16.7	91,300	8.0	
1902, April 10,	19.0	115,000	10.1	
1902, July 4,	20.0	125,000	11.0	
1903, January 31,	19.7	122,000	10.7	
1903, February 5,	23.5	165,000	14.5	
1903, March 1,	23.0 e	159,000	13.9	
1903, March 10,	19.3	118,000	10.4	
1903, March 12,	18.9 e	114,000	10.0	Estimated from hydrograph.
1904, January 23,	31.2 e	279,000	24.5	
1904, February 9,	20.8 e	134,000	11.8	Estimated from hydrograph.
1904, March 4,	28.9 e	242,000	21.2	
1904, March 8,	23.9	170,000	14.9	
1904, March 27,	19.5 e	120,000	10.5	Estimated from hydrograph.

TABLE No. 13—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
UNITED STATES WEATHER BUREAU RECORD—Continued.				
1904, April 2,	25.6	192,000	16.8	
1905, January 13,	16.0	85,000	7.5	
1905, March 9,	16.2	86,800	7.6	
1905, March 20,	32.0 e	292,000	25.6	
1905, March 28,	18.0	104,000	9.1	
1905, December 3,	20.3 e	129,000	11.3	
1906, March 28,	17.0 e	94,300	8.3	
1906, April 1,	16.4	88,600	7.8	
1907, January 20,	17.7 e	101,000	8.9	
1907, March 15,	28.0 e	228,000	20.0	
1907, March 20,	18.4	108,000	9.5	
1907, December 24,	18.7 e	111,000	9.7	Estimated from hydrograph.
1908, February 16,	28.5 e	236,000	20.7	Estimated from hydrograph.
1908, March 3,	17.7	101,000	8.9	
1908, March 7,	19.8	123,000	10.8	
1908, March 16,	18.0	104,000	9.1	
1908, March 19,	26.7 e	208,000	18.2	
1909, February 17,	19.8 e	123,000	10.8	Estimated from hydrograph.
1909, February 25,	20.8	134,000	11.8	
1909, May 1,	26.6 e	207,000	18.2	Estimated from hydrograph.
1910, January 19,	20.0 e	125,000	11.0	
1910, January 22,	18.0	104,000	9.1	
1910, February 17,	16.3 e	87,700	7.7	
1910, March 1,	24.8 e	181,000	15.9	Estimated from hydrograph.
1910, March 7,	22.7 e	155,000	13.6	Estimated from hydrograph.
1910, December 30,	17.7 e	101,000	8.9	
1911, January 4,	16.3	87,700	7.7	
1911, January 15,	22.4 e	152,000	13.3	
1911, January 29,	18.1 e	105,000	9.2	Estimated from hydrograph.
1911, September 16,	21.0 e	136,000	11.9	Estimated from hydrograph.
1911, October 2,	21.5 e	142,000	12.5	Estimated from hydrograph.
1912, February 27,	19.4 e	119,000	10.4	
1912, March 21,	23.8 e	169,000	14.8	
1912, March 31,	20.0 e	125,000	11.0	Estimated from hydrograph.
1912, April 3,	23.8 e	169,000	14.8	Estimated from hydrograph.
1912, September 4,	19.0 e	115,000	10.1	Estimated from hydrograph.
1913, January 8,	28.4 e	234,000	20.5	
1913, January 12,	22.6 e	154,000	13.5	Estimated from hydrograph.
1913, January 19,	16.7	91,300	8.0	
1913, March 27,	32.2 e	295,000	25.9	Estimated from hydrograph.
1914, February 1	18.7	111,000	9.7	
1914, March 29,	24.6 e	179,000	15.7	Estimated from hydrograph.
1914, May 13,	20.2 e	127,000	11.1	

Kiskiminitas River at Avonmore

The gage at Avonmore was established by the United States Geological Survey on May 29, 1907, but has been maintained and operated since that date by the Water Supply Commission. The flood record covering the period January 1, 1884, to June 1907 has been derived from the Signal Service and Weather Bureau gage readings taken on the Kiskiminitas River at Saltsburg, below the confluence of the Conemaugh River and Loyalhanna Creek, about 5 miles above Avonmore. No daily record was kept from November 21, 1895, to October 31, 1901, inclusive. The discharges in Table No. 14 are referred to two rating tables which were calculated from curves well defined below a gage height of 18 feet, the first table being applicable to December 31, 1912. The minimum annual flood stage is 13.4 feet.

TABLE No. 14. *Record of High Water on Kiskiminitas River at Avonmore (Drainage Area, 1,720 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1824, March 6,	.....	.....	.....	Greensburgh Gazette of March 21, 1824.
1831, July 7,	.....	.....	.....	
1832, February,	.....	.....	.....	Ice gorged.
1847, October 8,	.....	.....	.....	
1861, September 28,	.....	.....	.....	
1875, March,	.....	.....	.....	Ice gorged.
1881, February 10,	.....	.....	.....	Ice gorged.
ESTIMATED FROM SIGNAL SERVICE RECORD—SALTSBURG GAGE.				
1884, January 2,	16.2	26,700	15.5	
1884, February 1,	14.5	21,600	12.6	
1884, February 6,	24.1	54,200	31.5	
1884, February 14,	15.1	23,300	13.5	
1884, March 9,	15.1	23,300	13.5	
1884, March 12,	15.8	25,400	14.8	
				No record from May 1st to Oct. 25th.
1885, January 17,	16.4	27,300	15.9	
1885, April 1,	15.1	23,300	13.5	
1886, January 5,	19.1	36,200	21.0	
1886, February 13,	13.8	19,600	11.4	
1886, April 1,	13.8	19,600	11.4	
1886, December 14,	13.8	19,600	11.4	
1887, June 8,	13.4	18,500	10.8	
1888, January 8,	18.6	34,500	20.1	
1888, February 6,	14.3	21,000	12.2	
				No record from July 1st to September 30th.
1888, August 21,	31.8 c	84,500	49.1	Pittsburgh Commercial Gazette of June 1, 1889.
1889, March 5,	13.8	19,600	11.4	
1889, April 13,	13.8	19,600	11.4	
1889, June 1,	29.8	76,500	44.5	
1889, December 15,	15.0	23,000	13.4	
1890, February 15,	14.3	21,000	12.2	
1890, March 23,	17.8	31,800	18.5	
1890, April 10,	17.8	31,800	18.5	
1890, May 26,	13.8	19,600	11.4	
1890, September 10,	15.1	23,300	13.5	
1891, February 2,	13.5	18,800	10.9	
1891, February 10,	14.5	21,600	12.6	
1891, February 17,	30.4	78,900	45,9	
1891, June 22,	14.3	21,000	12.2	
1892, January 14,	15.1	23,300	13.5	
ESTIMATED FROM WEATHER BUREAU RECORD—SALTSBURG GAGE.				
1893, February 4,	13.8	19,600	11.4	
1893, February 7,	14.4	21,300	12.4	
1893, February 11,	15.2	23,600	13.7	
1893, March 10,	13.8	19,600	11.4	
1894, February 10,	13.8	19,600	11.4	
1894, May 20,	19.5	37,500	21.8	
1895, January 8,	19.8	38,600	22.4	
1895, March 1,	15.8	25,400	14.8	
1895, April 10,	17.4	30,500	17.7	
1895, April 14,	16.1	26,400	15.3	
				No record from November 21, 1895, to October 31, 1901.
1898, March 24,	.....	.....	.....	
1901, April 21,	.....	.....	.....	
1901, December 15,	16.4	27,300	15.9	
1902, January 27,	14.5	21,600	12.6	
1902, March 1,	26.4	63,200	36.7	
1902, March 13,	14.3	21,000	12.2	
1902, April 9,	16.4	27,300	15.9	
1902, July 1,	16.8	28,600	16.6	
1902, July 4,	14.0	20,200	11.7	

TABLE No. 14—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
ESTIMATED FROM WEATHER BUREAU RECORD, SALTSBURG GAGE—Continued.				
				No record from July 5th to 11th, inclusive.
1902, December 12,	13.8	19,600	11.4	
1903, January 30,	14.5	21,600	12.6	
1903, February 5,	14.5	21,600	12.6	
1903, March 1,	16.4	27,300	15.9	
				No record from July 7th to 18th, inclusive.
1904, January 23,	21.8	45,600	26.5	
1904, March 4,	16.4	27,300	15.9	
1904, March 8,	15.1	23,300	13.5	
1904, April 2,	16.4	27,300	15.9	
1904, July 10,	15.8 e	25,400	14.8	
1905, March 8,	20.4 e	40,700	23.7	
1905, March 21,	18.0 e	32,500	18.9	
1905, June 23,	13.4	18,500	10.8	
				No record from November 1st to 17th, inclusive.
1905, December 3,	19.1 e	36,200	21.0	
1906, January 24,	13.8 e	19,600	11.4	
1906, March 28,	15.1	23,300	13.5	
1906, June 7,	19.1 e	36,200	21.0	
1907, January 15,	17.1	29,500	17.2	
1907, January 20,	17.5	30,800	17.9	
1907, February 3,	17.8	31,800	18.5	
1907, February 21,	15.0	23,000	13.4	
1907, March 14,	33.8 e	92,500	53.8	
1907, March 20,	21.1	43,100	25.1	
WATER SUPPLY COMMISSION RECORD.				
1907, December 24,	17.5	30,800	17.9	
1908, January 13,	16.0	26,000	15.1	
1908, January 28,	13.8	19,600	11.4	
1908, February 16,	22.5 e	48,200	28.0	Estimated from hydrograph.
1908, March 3,	14.1	20,500	11.9	
1908, March 7,	17.8	31,800	18.5	
1908, March 19,	30.8 e	80,500	46.8	
1908, May 20,	13.4	18,500	10.8	
1909, February 24,	15.7	25,100	14.6	
1909, March 4,	13.7	19,400	11.3	
1909, May 1,	13.6 e	19,100	11.1	Estimated from hydrograph.
1910, January 19,	20.0	39,300	22.8	
1910, January 22,	17.2	29,800	17.3	
1910, February 17,	23.7 e	52,700	30.6	
1910, February 22,	19.0 e	35,800	20.8	
1910, March 1,	18.6 e	34,500	20.1	Estimated from hydrograph.
1910, June 19,	13.5 e	18,800	10.9	
1910, December 30,	14.2 e	20,800	12.1	
1911, January 15,	15.9 e	25,700	14.9	
1911, January 30,	14.7 e	22,200	12.9	
1911, April 6,	14.2 e	20,800	12.1	
1911, September 15,	21.5 e	44,600	26.0	Estimated from hydrograph
1912, January 20,	16.4 e	.....	.....	Ice gorged.
1912, January 24,	15.2 e	.....	.....	Ice gorged.
1912, February 22,	16.7 e	.....	.....	Ice gorged.
1912, February 27,	19.3 e	36,800	21.4	
1912, March 16,	17.2 e	29,800	17.3	
1912, March 21,	28.0 e	69,400	40.3	
1912, March 25,	14.1 e	20,500	11.9	
1912, May 17,	13.7 e	19,400	11.3	
1912, June 17,	18.5 e	34,100	19.8	
1912, July 22,	18.8 e	35,200	20.5	
1912, July 24,	14.7 e	22,200	12.9	
1912, September 3,	22.3 e	47,400	27.6	
				Second rating table.
1913, January 8,	22.2 e	44,700	26.0	
1913, January 12,	18.7 e	32,100	18.7	
1913, March 21,	16.1 e	24,000	14.0	
1913, May 27,	18.5 e	31,400	18.3	
1913, October 26.	13.9 e	17,900	10.4	

TABLE No. 14—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
WATER SUPPLY COMMISSION RECORD—Continued.				
1913, November 10,	14.5 c	19,500	11.3	
1914, February 20,	17.3 c	.....	.....	Ice gorged. Estimated from hydrograph.
1914, March 15,	17.6	.....	.....	Ice gorged.
1914, March 17,	17.2 c	27,300	15.9	
1914, March 28,	14.2 c	18,700	10.9	
1914, March 31,	14.2 c	18,700	10.9	
1914, April 16,	15.0 c	20,800	12.1	

Monongahela River at Lock No. 4

Daily gage readings were started December 9, 1885, by the United States Signal Service, using the gage of the Monongahela Navigation Company, the zero of which is 717.71 feet above sea level. From January 1, 1890, to date, gage readings have been published by the United States Weather Bureau. The flood record in Table No. 15 has been extended back to 1873 by utilizing the readings taken at New Geneva by the United States Signal Service for the period April 23, 1873, to December 9, 1885, a fairly permanent relation having been established between this gage and the one at Lock No. 4. The discharge is computed from a rating table prepared by the United States Geological Survey, based upon current meter measurements of the flow made by it at Belle Vernon, and from surface slope data furnished by Col. T. P. Roberts, Corps of United States Engineers. The minimum annual flood stage is 19.0 feet.

TABLE No. 15. *Record of High Water on Monongahela River at Lock No. 4 (Drainage Area, 5,370 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1807, May 18,	.....	.....	.....	Pittsburgh Gazette, May 19, 1807. Cramer's Navigator, 1808, mentions height of 37 feet at Brownsville.
1810, November 10,	.....	.....	.....	Cramer's Navigator, 1824, page 18.
1824, March 6,	.....	.....	.....	Monongahela Navigation Company reported height of 40 feet at Brownsville.
1832, February 10,	.....	.....	.....	
1843, September 11,	.....	.....	.....	Reports of Monongahela Navigation Company.
1845,	.....	.....	.....	Reports of Monongahela Navigation Company.
1846, July 25,	.....	.....	.....	Reports of Monongahela Navigation Company mention height of about 40 feet above low water.
1852, April 6,	.....	.....	.....	Height of 34 feet at Fairmont Dam, W. Va. Highest since 1832, but not as high as flood of July 11, 1888.
1860, April 12,	.....	.....	.....	
1865, May 13,	.....	.....	.....	
ESTIMATED FROM SIGNAL SERVICE RECORD—NEW GENEVA GAGE.				
1873, May 4,	20.0	51,300	9.6	
1874, December 29,	19.0 e	46,100	8.6	Estimated from hydrograph.
1875, August 3,	27.0	92,600	17.2	
1876, September 18,	20.0 e	51,300	9.6	Estimated from hydrograph.
1877, January 13,	20.5	54,000	10.1	
1877, January 16,	36.8	165,000	30.7	
1877, January 21,	19.8	50,200	9.3	
1877, November 24,	20.0	51,300	9.6	
1878, November 28,	20.2	52,400	9.8	
1878, December 11,	21.2	57,900	10.8	
1879, December 25,	19.7 e	49,600	9.2	Estimated from hydrograph.
1880, February 14,	28.4	102,000	19.0	
1880, April 26,	20.7	55,200	10.3	
1880, June 15,	21.7	60,600	11.3	
1880, December 5,	22.5	65,000	12.1	
1881, January 21,	27.2	94,000	17.5	
1882, January 14,	23.3	69,600	13.0	
1882, January 27,	24.4	76,200	14.2	
1882, February 10,	19.2	47,100	8.8	
1882, February 18,	19.0	46,100	8.6	
1882, February 21,	22.3	64,000	11.9	
1882, March 21,	25.5	82,800	15.4	
1882, April 27,	22.2	63,400	11.8	
1882, July 2,	20.5	54,000	10.1	
1883, February 7,	29.4	109,000	20.3	
1883, February 12,	32.3	130,000	24.2	
1883, February 16,	22.3	64,000	11.9	
1883, March 31,	25.1	80,400	15.0	
1883, April 7,	20.3	53,000	9.9	
1883, November 30,	19.1	46,600	8.7	
1883, December 24,	29.0	107,000	19.9	
1884, January 2,	21.8	61,200	11.4	
1884, February 1,	23.6	71,400	13.3	
1884, February 6,	25.6	83,400	15.5	
1884, February 12,	19.4	48,100	9.0	
1884, February 15,	19.5	48,600	9.1	
1884, March 9,	23.6	71,400	13.3	
1884, April 3,	19.0	46,100	8.6	
1884, December 23,	21.8	61,200	11.4	
1885, January 17,	26.2	87,000	16.2	
1885, March 3,	21.1	57,400	10.7	
UNITED STATES SIGNAL SERVICE RECORD.				
1886, April 1,	27.5 c	96,100	17.9	Estimated from hydrograph.
1886, April 6,	27.5 c	96,100	17.9	Estimated from hydrograph.
1886, May 9,	22.0	62,300	11.6	
1886, May 15,	24.7 c	78,000	14.5	Estimated from hydrograph.
1886, June 18,	19.6	49,100	9.1	

TABLE No. 15—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
SERVICE RECORD—Continued. UNITED STATES SIGNAL	Feet.	Second-feet.	Second-feet.	
1887, February 4,	31.0	121,000	22.5	
1887, February 27,	28.5 c	103,000	19.2	Estimated from hydrograph.
1887, April 24,	22.6 c	65,600	12.2	Estimated from hydrograph.
1888, January 8,	22.0 c	62,300	11.6	Estimated from hydrograph.
1888, July 11,	42.0 c	207,000	38.5	Estimated from hydrograph.
1888, August 22,	31.0	121,000	22.5	
1889, February 18,	27.0	92,600	17.2	
1889, April 14,	21.0	56,800	10.6	
1889, June 1,	25.0	79,800	14.9	
1889, November 10,	21.4	59,000	11.0	
1889, November 15,	19.0	46,100	8.6	
UNITED STATES WEATHER BUREAU RECORD.				
1890, January 8,	20.5	54,000	10.1	
1890, January 17,	19.1	46,600	8.7	
1890, February 4-5,	21.1	57,400	10.7	
1890, February 9,	20.0	51,300	9.6	
1890, February 21,	23.5	70,800	13.2	
1890, March 23,	31.8	126,000	23.5	
1890, May 21,	19.0	46,100	8.6	
1890, October 14,	24.3	75,600	14.1	
1891, January 3,	31.3	123,000	22.9	
1891, January 13,	19.9	50,800	9.5	
1891, February 2,	19.3	47,600	8.9	
1891, February 11,	24.0	73,800	13.7	
1891, February 17,	21.8	61,200	11.4	
1891, February 23,	20.4	53,500	10.0	
1891, March 9,	19.5	48,600	9.1	
1891, April 4,	20.0	51,300	9.6	
1891, July 9,	19.0	46,100	8.6	
1892, January 15,	28.5	103,000	19.2	
1892, April 24,	21.6	60,100	11.2	
1893, January 30,	23.5	70,800	13.2	
1893, April 22,	19.3	47,600	8.9	
1894, February 5,	19.0 c	46,100	8.6	Estimated from hydrograph.
1895, January 8,	30.0	114,000	21.2	
1895, January 11,	21.0	56,800	10.6	
1895, March 2,	19.0	46,100	8.6	
1895, March 17,	21.7	60,600	11.3	
1895, April 10,	19.6	49,100	9.1	
1896, March 20,	20.5	54,000	10.1	
1896, July 23,	29.9	113,000	21.0	
1896, July 25,	38.0	175,000	32.6	
1896, July 31,	25.3	81,600	15.2	
1897, February 8,	19.0	46,100	8.6	
1897, February 23,	41.0 c	199,000	37.1	Estimated from hydrograph
1897, May 15,	20.6	54,600	10.2	
1897, December 6,	20.6	54,600	10.2	
1898, January 11,	23.9	73,200	13.6	
1898, January 17,	21.0	56,800	10.6	
1898, January 24,	21.9	61,800	11.5	
1898, March 18,	20.0	51,300	9.6	
1898, March 22,	22.5	65,000	12.1	
1898, March 25,	24.7	78,000	14.5	
1898, March 30,	23.9	73,200	13.6	
1898, April 26,	20.0	51,300	9.6	
1898, May 18,	19.0	46,100	8.6	
1898, August 11,	23.3	69,600	13.0	
1898, October 23,	21.6	60,100	11.2	
1898, December 21,	19.0	46,100	8.6	
1899, January 7,	23.5	70,800	13.2	
1899, January 15,	19.5	48,600	9.1	
1899, February 5,	22.0	62,300	11.6	
1899, March 6,	26.9	91,900	17.1	
1899, March 29-30,	23.0	67,800	12.6	
1899, May 19,	19.5	48,600	9.1	
1900, February 9,	19.2	47,100	8.8	
1900, March 2,	21.0	56,800	10.6	
1900, March 21,	19.0	46,100	8.6	
1900, November 27,	33.8	141,600	26.3	
1901, April 5,	21.6	60,100	11.2	
1901, April 7,	23.1	68,400	12.7	
1901, April 20,	26.5	89,100	16.6	

TABLE No. 15—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
UNITED STATES WEATHER BUREAU RECORD—Continued.	Feet.	Second-feet.	Second-feet.	
1901, May 28,	21.3	58,400	10.9	
1901, December 16,	28.5	103,000	19.2	
1901, December 30,	25.0	79,800	14.9	
1902, January 28,	25.9	85,200	15.9	
1902, February 27,	21.5	59,600	11.1	
1902, March 1,	30.0	114,000	21.2	
1902, March 10,	21.6	60,100	11.2	
1902, April 12,	22.7	66,200	12.3	
1902, December 14,	26.2	87,000	16.2	
1902, December 17,	26.0	85,800	16.0	
1903, January 4,	22.1	62,800	11.7	
1903, February 5,	21.7	60,600	11.3	
1903, February 17,	28.4	102,000	19.0	
1903, March 1,	32.5	131,000	24.4	
1903, March 9,	19.0	46,100	8.6	
1903, March 24,	23.2	69,000	12.8	
1904, January 23,	21.2	57,900	10.8	
1904, March 8,	19.5	48,600	9.1	
1904, March 24,	20.2	52,400	9.8	
1905, January 13,	24.0	73,800	13.7	
1905, March 10,	32.1 e	128,000	23.8	
1905, March 22,	27.2	94,000	17.5	
1905, May 13,	19.0	46,100	8.6	
1905, December 3,	24.5 e	76,800	14.3	Estimated from hydrograph.
1906, January 24,	23.0	67,800	12.6	
1906, March 16,	22.8	66,700	12.4	
1906, March 20,	20.5	54,000	10.1	
1906, April 27,	25.8	84,600	15.8	
1906, November 21,	20.0	51,300	9.6	
1906, December 12,	23.0	67,800	12.6	
1906, December 19,	21.3	58,400	10.9	
1907, January 10,	23.5	70,800	13.2	
1907, January 13,	26.9	91,900	17.1	
1907, January 15,	25.7	84,000	15.6	
1907, January 18,	36.6	164,000	30.5	
1907, February 3,	21.6	60,100	11.2	
1907, March 14,	37.4	170,000	31.7	
1907, March 20,	22.6	65,600	12.2	
1907, June 15,	20.9	56,200	10.5	
1907, July 19,	26.0	85,800	16.0	
1907, December 12,	19.0	46,100	8.6	
1908, January 14,	20.3	53,000	9.9	
1908, February 16,	28.5	103,000	19.2	
1908, March 3,	24.0	73,800	13.7	
1908, March 8,	19.5	48,600	9.1	
1908, March 10,	22.8	66,700	12.4	
1908, March 20,	23.0	67,800	12.6	
1908, April 1,	19.0	46,100	8.6	
1908, May 6,	25.3	81,600	15.2	
1908, May 8,	23.6	71,400	13.3	
1908, May 11,	20.0	51,300	9.6	
1909, February 17,	20.0	51,300	9.6	
1909, February 24,	22.5	65,000	12.1	
1909, April 23,	21.1	57,400	10.7	
1910, January 4,	24.0	73,800	13.7	
1910, January 8,	20.7	55,200	10.3	
1910, January 19,	26.8 e	91,200	17.0	Estimated from hydrograph.
1910, January 22,	20.2	52,400	9.8	
1910, February 23,	20.0	51,300	9.6	
1910, June 19,	26.5 e	89,100	16.6	Estimated from hydrograph.
1911, January 14,	28.8	105,000	19.6	
1911, January 30,	36.7 e	165,000	30.7	Estimated from hydrograph
1911, April 6,	23.2	69,000	12.8	
1911, September 1,	20.6	54,600	10.2	
1911, September 17,	23.2	69,000	12.8	
1911, October 9,	21.8	61,200	11.4	
1911, October 19,	20.3	53,000	9.9	
1912, January 20,	20.4	53,500	10.0	
1912, February 22,	20.5	54,000	10.1	
1912, February 28,	23.5	70,800	13.2	
1912, March 16,	27.7	97,500	18.2	
1912, March 22,	27.5	96,100	17.9	
1912, March 25,	21.8	61,200	11.4	
1912, July 26,	34.5 e	147,000	27.4	Estimated from hydrograph.
1913, January 8,	30.4 e	116,000	21.6	Estimated from hydrograph.

TABLE No. 15—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
UNITED STATES WEATHER BUREAU RECORD—Continued.				
1913, January 12,	28.3 c	102,000	19.0	Estimated from hydrograph.
1913, March 28,	25.2	81,000	15.1	
1913, May 24,	22.5	65,000	12.1	
1913, May 29,	23.9	73,200	13.6	
1913, November 15,	30.9	120,000	22.3	
1913, November 17,	36.6 c	164,000	30.5	Estimated from hydrograph.
1914, February 20,	26.9 c	91,900	17.1	Estimated from hydrograph.
1914, April 3,	19.7	49,600	9.2	

Youghiogheny River at Connellsville

The record in Table No. 16 is referred to the gage of the Water Supply Commission established July 22, 1908, on the highway bridge across the Youghiogheny River connecting Connellsville and New Haven. For the period November 1, 1890, to August, 1895, the gage heights were derived from the Weather Bureau gage readings taken at West Newton, and for the period September, 1895, to July 22, 1908, gage heights were computed from the gage readings taken at the pumping plant of the Trotter Water Company, located about 2 miles above Connellsville. The zero of the Water Supply Commission gage is 860.13 feet above sea level. The discharges are referred to a rating curve which is well defined below a gage height of 12 feet. The minimum annual flood stage is 8.9 feet.

TABLE No. 16. *Record of High Water on Youghiogheny River at Connellsville (Drainage Area, 1,320 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS.				All data approximate.
1816, February,	.....	.....	.....	Ice gorge destroyed highway bridge.
1831, February,	.....	.....	.....	Ice gorge destroyed highway bridge.
1852, April 6,	.....	.....	.....	
1860, April 12,	16.5	47,000	35.6	

TABLE No. 16—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
	Feet.	Second-feet.	Second-feet.	
EARLY FLOODS—Continued.				
1865, May 13,	.....	.....	.....	Destroyed dams of the Youghiogheny Slack Water Company.
1876, September 18,	.....	.....	.....	
1888, August 21-22,	17.8	52,000	39.4	
ESTIMATED FROM WEATHER BUREAU RECORD — WEST NEWTON GAGE.				
1891, February 2,	10.1	22,000	16.7	
1891, February 11,	9.7	20,400	15.5	
1891, February 17,	14.7 c	39,900	30.2	
1891, June 8,	9.6	20,000	15.2	
1892, January 15,	10.2	22,400	17.0	
1893, February 11,	9.8	20,800	15.8	
1894, February 10,	8.9	17,400	13.2	
1895, January 8,	12.0	29,400	22.3	
1895, March 2,	9.4	19,300	14.6	
1895, April 10,	9.8	20,800	15.8	
ESTIMATED FROM TROTTER WATER COMPANY RECORD.				
1896, July 25,	15.0 c	41,100	31.1	Estimated from hydrograph.
1896, July 28,	9.5 c	19,600	14.9	
1897, February 23,	16.7 c	47,700	36.1	
1897, March 6,	9.0	17,800	13.5	
1898, March 23,	11.0 c	25,500	19.3	Estimated from hydrograph.
1898, August 11,	11.2 c	26,300	19.9	
1899, January 15,	9.1	18,100	13.7	Estimated from West Newton record.
1899, May 18,	13.0 c	33,300	25.2	Estimated from hydrograph.
1900, November 26,	11.7	28,200	21.4	
1901, March 11,	10.4 c	23,200	17.6	Estimated from hydrograph.
1901, April 6,	11.5	27,400	20.8	
1901, April 21,	10.5 c	23,600	17.9	Estimated from hydrograph.
1901, May 27,	9.9	21,200	16.1	
1901, December 15,	11.7	28,200	21.4	
1902, February 28,	15.8 c	44,200	33.5	
1902, March 13,	10.3	22,800	17.3	
1902, April 12,	10.0 c	21,600	16.4	Estimated from hydrograph.
1902, December 12,	9.9 c	21,200	16.1	Estimated from hydrograph.
1902, December 17,	9.6	20,000	15.2	
1903, January 30,	11.0 c	25,500	19.3	Estimated from hydrograph.
1903, February 14,	12.0	29,400	22.3	
1903, February 28,	12.7	32,100	24.3	
1904, January 22,	12.9 c	32,900	24.9	Estimated from hydrograph.
1904, March 1,	13.7	36,000	27.3	Estimated from West Newton record.
1904, March 4,	10.3	22,800	17.3	Estimated from West Newton record.
1905, March 10,	9.4	19,300	14.6	
1905, March 21,	12.0 c	29,400	22.3	Estimated from hydrograph.
1905, December 4,	9.6	20,000	15.2	Estimated from West Newton record.
1906, January 23,	10.9 c	25,100	19.0	Estimated from West Newton record.
1906, March 31,	9.4 c	19,300	14.6	Estimated from hydrograph.
1906, August 10,	9.4	19,300	14.6	
1907, January 15,	12.8 c	32,500	24.6	Estimated from hydrograph.
1907, January 20,	13.5 c	35,200	26.7	Estimated from hydrograph.
1907, March 14,	18.4 c	54,400	41.2	Determined from high water marks.
1907, March 19,	14.3 c	38,400	29.1	
1907, December 24,	9.4	19,300	14.6	
1908, February 15,	14.4	38,800	29.4	
1908, March 7,	11.5 c	27,400	20.8	
1908, March 19,	12.7 c	32,100	24.3	
1908, May 7,	10.3	22,800	17.3	
WATER SUPPLY COMMISSION RECORD.				
1909, February 24,	9.6 c	20,000	15.2	Estimated from hydrograph.
1909, April 22,	9.1 c	18,100	13.7	Estimated from hydrograph.
1910, January 3,	11.6 c	27,800	21.1	Estimated from hydrograph.
1910, January 19,	12.0 c	29,400	22.3	Estimated from hydrograph.
1910, January 22,	9.0	17,800	13.5	Estimated from West Newton record.

TABLE No. 16—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.
WATER SUPPLY COMMISSION RECORD—Continued.	Feet.	Second-feet.	Second-feet.	
1910, March 1,	9.2 e	18,500	14.0	Estimated from hydrograph.
1910, June 19,	13.1 c	33,700	25.5	
1911, January 13,	12.7 c	32,100	24.3	
1911, January 30,	12.8 c	32,500	24.6	
1911, April 6,	10.1 c	22,000	16.7	Estimated from hydrograph.
1911, August 31,	9.5 c	19,600	14.9	Estimated from hydrograph.
1911, September 16,	10.4 c	23,200	17.6	Estimated from hydrograph.
1912, February 27,	12.8 c	32,500	24.6	
1912, March 16,	14.0 c	37,200	28.2	Estimated from hydrograph.
1912, March 21,	17.3 c	50,100	37.9	
1912, May 16,	9.6 e	20,000	15.2	Estimated from hydrograph.
1912, July 22,	9.5 c	19,600	14.9	Estimated from hydrograph.
1912, July 25,	13.5 c	35,200	26.7	Estimated from hydrograph.
1912, September 3,	9.7 c	20,400	15.5	Estimated from hydrograph.
1912, September 27,	9.0 c	17,800	13.5	
1913, January 8,	13.5 c	35,200	26.7	
1913, January 12,	11.5 c	27,400	20.8	Estimated from hydrograph.
1913, May 24,	9.2 c	18,500	14.0	Estimated from hydrograph.
1913, May 28,	10.0 c	21,600	16.4	Estimated from hydrograph.
1913, November 14,	10.1 c	22,000	16.7	Estimated from hydrograph.
1913, November 16,	11.4 c	27,100	20.5	Estimated from hydrograph.
1914, March 17,	9.1 c	18,100	13.7	
1914, April 2,	9.1 c	18,100	13.7	Estimated from hydrograph.

Ohio River at Pittsburgh

The first daily gage record at Pittsburgh was started August 1, 1854, under the direction of the United States Engineer Corps. In 1872 the record was taken over by the Signal Service, which continued it until July, 1891, when the United States Weather Bureau took charge of the gage, and has kept the record to date. From 1858 to October 16, 1907, the gage was located on the Monongahela River at the foot of Market Street. On the latter date the Weather Bureau installed a self-recording gage at the Point Bridge, which is still in use. Both gages refer to the same datum, which is 697.2 feet above sea level. The Market Street gage, owing to its being farther upstream, gave readings slightly higher than those of the present gage, but the difference was not material except when the Monongahela River was in flood and the Allegheny River was low. The heights of early floods were obtained from a number of sources, principal among which are the following: the record published in "Historical Gleanings of Allegheny, Pa.," 1886, by Judge John E. Parke; the Allegheny River gage record, published by the Signal Service and obtained from a gage at the Sixth Street Bridge, the datum of which is reported to have been identical with that of the Market Street gage;

the private meteorological record of the late George Albree of Pittsburgh, which contained many flood heights; records compiled by Captain James Atkinson, at the Smithfield Bridge, and Mr. David Parker at the same bridge; flood heights compiled by the late William M. Darlington, of Sharpsburg. In addition, references to floods were found in early letters, newspapers and various publications, notable among the latter being Zadok Cramer's Navigator, a handbook for rivermen, published in 1808 and some years thereafter. The stages of the floods of 1762 and 1763, which are the highest on record, were computed from information contained in letters written at Fort Pitt, January 12, 1762, by Col. Henry Bouquet, and March 11, 1763, by Captain Ecuyer, the originals of which are on file in the British Museum, London.

A discharge table for the Ohio River has been computed from measurements made by the United States Engineer Corps at Jacks Run, and referred to the gage at Davis Island Dam. This dam, which is about 4 miles below Pittsburgh, is collapsed during high water and does not affect the height of floods at Pittsburgh. A gage has been maintained at the dam since October 7, 1885, when it was put in operation, and a relation has been established by the Commission between the lower gage at the dam and the Pittsburgh gage for flood stages. In this manner it has been possible to compute the discharge for any flood height on the Pittsburgh gage. No attempt has been made to allow for differences in discharge caused by changes in the channel which have taken place during the period covered by the record, on account of the indeterminate character of such differences. Only one rating curve has, therefore, been used for computing the discharges given in Table No. 17. In addition to the usual data, Table No. 17 indicates, wherever it could be determined, the name of the tributary or tributaries which were primarily responsible for causing the flood stage at Pittsburgh. The minimum annual flood stage is 17.5 feet.

TABLE No. 17. *Record of High Water on Ohio River at Pittsburgh (Drainage Area, 19,000 square miles)*

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.	Tributaries Causing Flood.
EARLY FLOODS.	Feet.	Second-feet.	Second-feet.	All data approximate.	
1756, Spring,	.....	.....	.....	From letter written at Fort Duquesne, May, 1756.	
1762, January 9,	36 c	443,000	23	From letter, written at Fort Pitt, January 12, 1762.	
1763, March 9,	38 c	477,000	25	From letter written at Fort Pitt, March 11, 1763.	
1764, March 28,	.....	.....	.....	From William M. Darlington's record, ...	
1772,	.....	.....	.....	From William M. Darlington's record, ...	
1784,	35 c	426,000	22	From William M. Darlington's record, ...	
1787, January,	32 c	375,000	20	From William M. Darlington's record; also mentioned in Pittsburgh Gazette, January 13, 1787.	Allegheny and Monongahela.
1789, January,	.....	.....	.....	From William M. Darlington's record, ...	
1794, December 20,	.....	.....	.....	From William M. Darlington's record, ...	
1806, April 10,	33.9 c	407,000	21.4	From Judge John E. Parke's "Historical Gleanings of Allegheny, Pa.," (1886).	Allegheny.
1807, May 18,	26.9 c	294,000	15.5	From History of Pittsburgh, by Erasmus Wilson; also mentioned in Pittsburgh Gazette, May 19, 1807.	Monongahela.
1810, November 11,	32.0 c	375,000	19.7	From Allegheny River gage record, ...	Allegheny and Monongahela.
1813, January,	29.0 c	327,000	17.2	From Judge John E. Parke's "Historical Gleanings of Allegheny, Pa.," (1886).	
1816, February,	33.0 c	392,000	20.6	.....	Allegheny (Kiskiminitas) and Monongahela (Youghiogheny).
1824, March 6-7,	.....	.....	.....	.....	Allegheny (Kiskiminitas) and Monongahela.
1828, January,	.....	.....	.....	.....	Allegheny.
1832, February 10,	35.0 c	426,000	22.4	.....	Allegheny and Monongahela.
1840, February 1,	26.8 c	293,000	15.4	From Allegheny River gage record, ...	Allegheny.
1846, March 15,	25.0 c	266,000	14.0	From Allegheny River gage record, ...	
1846, December 20,	20	192,000	10	From George Albree's record, ...	
1847, February 2,	26.9	294,000	15.5		
1847, November 25,	25	266,000	14	From George Albree's record, ...	
1847, December 12,	24.0	251,000	13.2	From Allegheny River gage record, ...	
1847, December 18,	18	164,000	9	From George Albree's record, ...	

TABLE No. 17—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.	Tributaries Causing Flood.
EARLY FLOODS—Continued.	Feet.	Second-feet.	Second-feet.		
1848, December 22,	23	236,000	12	From Allegheny River gage and George Albree's record.	
1850, December 8,	20	192,000	10	From George Albree's record,	
1851, September 20,	30.9	357,000	18.8	From Judge John E. Parke's "Historical Gleanings of Allegheny, Pa." (1886).	
1852, April 6,	27.0	296,000	15.6	From Allegheny River gage record. According to Pittsburgh Post, April 20, 1851, river during night attained a height of over 27 feet.	Monongahela.
1852, April 19,	31.9	373,000	19.6	Height was 33.0 feet according to Allegheny River gage record. Pittsburgh Post, April 21, 1852, states stage was within 3 feet of 1832 flood and was maintained from midnight April 19 to 6 a. m. April 20, 1852.	Allegheny.
UNITED STATES ENGINEER CORPS RECORD.					
1855, March 18,	18.0	164,000	8.6		
1856, April 14-15,	19.5	185,000	9.7		
1856, April 18,	18.5	171,000	9.0		
1857, May 6,	21.3	211,000	11.1		
1857, December 11,	18.0	164,000	8.6		
1858, May 27,	26.0 c	281,000	14.8		
1858, December 16,	20.0 c	192,000	10.1		
1859, February 20,	20.0	192,000	10.1		
1859, April 23,	19.2	181,000	9.5		
1859, April 27-28,	22.0	221,000	11.6		
1860, January 15,	18.0	164,000	8.6		
1860, April 12,	29.7 c	338,000	17.8		Monongahela.
1860, November 4,	22.0	221,000	11.6		

1861, September 29,	31.0	359,000	18.9	River rose from a height of 4.0 feet on September 27th to 30.5 feet on September 28th.	Allegheny.
1861, November 4,	18.0	164,000	8.6		
1862, January 21,	30.0 c	343,000	18.1	Above 26 feet from morning of January 19th to morning of January 22d.	
1862, April 9,	19.5	185,000	9.7		
1862, April 22,	25.4 c	272,000	14.3		
1863, December 16,	18.4	169,000	8.9		
1864, April 11,	18.0	164,000	8.6		
1864, December 18,	19.5	185,000	9.7		
1864, December 20,	19.5	185,000	9.7		
1865, March 4,	24.5 c	258,000	13.6		
1865, March 19,	31.4 c	365,000	19.2		Allegheny.
1865, April 1,	19.0	178,000	9.4		
1865, May 13,	21.6 c	215,000	11.3		Monongahela.
1865, December 23,	18.0	164,000	8.6		
1866, February 14,	17.5	156,000	8.2		
1867, February 15-16,	22.0 c	221,000	11.6		
1867, March 13,	23.5	244,000	12.8		
1868, March 18,	22.0 c	221,000	11.6		
1868, September 26,	18.0	164,000	8.6		
1869, March 31,	19.5	185,000	9.7		
1870, January 19,	18.0	164,000	8.6		
1871, January 17,	18.5	171,000	9.0		
UNITED STATES SIGNAL SERVICE RECORD—MARKET STREET GAGE.					
1872, April 11,	20.6 c	201,000	10.6		
1873, January 6,	20.2	195,000	10.3		Monongahela.
1873, May 4,	18.5	171,000	9.0		Allegheny.
1873, December 14,	25.7 c	276,000	14.5		Allegheny.
1874, January 8,	22.6 c	230,000	12.1		Allegheny and Monongahela.
1874, December 30,	21.0 c	206,000	10.8		Allegheny.
1875, March 16,	20.5	199,000	10.5		Allegheny.
1875, April 3,	18.0	164,000	8.6		Monongahela.
1875, August 3,	21.9 c	220,000	11.6		Allegheny.
1875, December 28,	21.6 c	215,000	11.3		Monongahela (Youghiogheny).
1876, September 19,	25.0 c	266,000	14.0		Monongahela.
1877, January 17,	24.6 c	260,000	13.7	Backwater on Allegheny caused ice jams.	Monongahela.
1877, November 25,	18.2	166,000	8.7		Monongahela.
1878, November 28,	18.7	174,000	9.2		Allegheny and Monongahela.
1878, December 11,	24.5 c	258,000	13.6		Allegheny.
1879, January 29,	19.8	189,000	10.0		Allegheny.
1879, March 12,	19.9	191,000	10.1		Allegheny and Monongahela.
1880, February 14,	21.6	215,000	11.3		Monongahela.
1880, December 6,	18.5	171,000	9.0		
1881, February 11,	23.2	239,000	12.6		Allegheny.
1881, April 14,	18.5	171,000	9.0		Allegheny.
1881, June 10,	27.1 c	298,000	15.7		Monongahela.
1882, January 14,	18.0	164,000	8.6		Allegheny and Monongahela.
1882, January 28,	21.5	214,000	11.3		Allegheny and Monongahela.
1882, February 22,	21.1	208,000	10.9		Monongahela.
1882, March 22,	18.3	168,000	8.8		

TABLE No. 17—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.	Tributaries Causing Flood.
UNITED STATES SIGNAL SERVICE RECORD—MARKET STREET GAGE—Continued.	Feet.	Second-feet.	Second-feet.		
1883, February 5,	24.8	263,000	13.8		Allegheny.
1883, February 8,	28.0 e	312,000	16.4		Monongahela.
1883, February 12,	20.6	201,000	10.6		Monongahela.
1883, February 16,	20.7	202,000	10.6		Allegheny.
1883, December 25,	18.8	175,000	9.2		Monongahela.
1884, February 1,	20.4	198,000	10.4		Monongahela.
1884, February 6,	33.3 e	397,000	20.9		Allegheny and Monongahela.
1884, February 15,	20.8	204,000	10.7		Allegheny and Monongahela.
1884, March 13,	18.9	177,000	9.3		Allegheny.
1885, January 17,	23.0 e	236,000	12.4		Monongahela.
1886, January 6,	20.2	195,000	10.3		Allegheny and Monongahela.
1886, February 14,	19.5	185,000	9.7		Allegheny.
1886, April 1,	20.0	192,000	10.1		Allegheny and Monongahela.
1886, April 7,	22.6 e	230,000	12.1		Allegheny and Monongahela.
1887, February 4,	20.0	192,000	10.1		Monongahela.
1887, February 9,	19.0	178,000	9.4		Allegheny.
1887, February 12,	22.0 e	221,000	11.6		Allegheny.
1887, February 27,	22.0 e	221,000	11.6		Monongahela.
1888, January 8,	21.3	211,000	11.1		Allegheny.
1888, July 11,	22.0 e	221,000	11.6		Monongahela (Cheat).
1888, August 22,	26.0 e	281,000	14.8		Allegheny (Kiskiminitas) and Monongahela (Youghiogheny).
1889, February 19,	18.0 e	164,000	8.6		Monongahela.
1889, June 1,	24.0 e	251,000	13.2		Allegheny (Kiskiminitas).
1890, January 17,	20.0 e	192,000	10.1		Allegheny.
1890, February 21,	18.3	168,000	8.8		Allegheny.
1890, March 24,	24.3 e	256,000	13.5		Allegheny and Monongahela.
1890, April 10,	18.8 e	175,000	9.2		Allegheny.
1890, May 24,	22.0 e	221,000	11.6		Allegheny.
1891, January 3,	23.2 e	239,000	12.6		Allegheny and Monongahela.
1891, February 11,	19.7	188,000	9.9		Allegheny.
1891, February 18,	31.3 e	364,000	19.2		Allegheny (Kiskiminitas) and Monongahela (Youghiogheny).

UNITED STATES WEATHER BUREAU RECORD—MARKET STREET GAGE.				
1892. January 15,	23.0 c	236,000	12.4	Allegheny and Monongahela.
1893, February 8,	24.0 c	251,000	13.2	Allegheny.
1893, February 11,	22.0 c	221,000	11.6	Allegheny.
1893, May 18,	19.8	189,000	10.0	Allegheny.
1894, May 22,	23.2 c	239,000	12.6	Allegheny (Kiskiminitas).
1895, January 8,	25.8 c	278,000	14.6	Monongahela.
1895, April 11,	20.2	195,000	10.3	Allegheny.
1896, March 31,	20.6	201,000	10.6	Allegheny.
1896, July 26,	23.0 c	236,000	12.4	Monongahela.
1897, February 24,	29.5 c	335,000	17.6	Monongahela (Cheat and Youghiogheny).
1897, March 7,	18.7	174,000	9.2	Allegheny.
1898, January 24,	19.7	188,000	9.9	Monongahela.
1898. March 24,	28.9 c	325,000	17.1	Allegheny (Clarion, Mahoning and Red Bank).
1899, March 6,	22.0 c	221,000	11.6	Monongahela.
1899, March 30,	19.2	181,000	9.5	Monongahela.
1900, January 12,	17.8	161,000	8.5	Allegheny.
1900. November 27,	27.7 c	307,000	16.2	General over entire basin.
1901, March 12,	19.8 c	189,000	10.0	Allegheny.
1901, April 7,	22.1 c	222,000	11.7	Monongahela.
1901, April 21,	27.5 c	304,000	16.0	Allegheny and Monongahela.
1901, December 16,	25.8 c	278,000	14.6	Monongahela.
1902, March 1,	32.4 c	382,000	20.1	Allegheny and Monongahela.
1902, April 10,	20.6 c	201,000	10.6	Allegheny.
1903, January 31,	21.0 c	206,000	10.8	Allegheny.
1903, February 5,	24.0 c	251,000	13.2	Allegheny.
1903, February 17,	21.9 c	220,000	11.6	Monongahela.
1903, March 1,	28.9 c	325,000	17.1	General over entire basin.
1903, March 10,	20.1 c	193,000	10.2	Allegheny.
1904, January 23,	30.0 c	343,000	18.1	Allegheny (Clarion and French) and Monongahela (Youghiogheny).
1904, February 9,	19.8 c	189,000	10.0	
1904, March 4,	26.9 c	294,000	15.5	Allegheny (Clarion, Mahoning and Red Bank).
1904, March 8,	23.2 c	239,000	12.6	Allegheny.
1904, April 2,	21.9 c	220,000	11.6	Allegheny.
1905, March 11,	20.4 c	198,000	10.4	Monongahela.
1905, March 22,	29.0 c	327,000	17.2	Allegheny (Clarion and French) and Monongahela.
1905, December 4,	23.5 c	244,000	12.8	Monongahela.
1906, April 1,	18.8 c	175,000	9.2	Allegheny (Kiskiminitas).
UNITED STATES WEATHER BUREAU RECORD—POINT BRIDGE GAGE.				
1907, January 20,	23.3 c	240,000	12.6	Monongahela (Youghiogheny).
1907, March 15,	35.5 c	434,000	22.8	Allegheny (Kiskiminitas) and Monongahela (Youghiogheny).
1907, March 20,	22.4 c	227,000	12.0	Allegheuy (Kiskiminitas) and Monongahela.
1907, December 25,	18.7	174,000	9.2	Allegheny.
1908, January 14,	20.3 c	196,000	10.3	Allegheny (Kiskiminitas) and Monongahela.
1908, February 16,	30.7 c	354,000	18.6	Allegheny and Monongahela.

TABLE No. 17—Continued

Date.	Gage height.	Discharge.	Discharge per square mile.	Notes.	Tributaries Causing Flood.
UNITED STATES WEATHER BUREAU RECORD—POINT BRIDGE GAGE—Continued.	Feet.	Second-feet.	Second-feet.		
1908, March 3,	20.5 e	199,000	10.5		Monongahela.
1908, March 8,	20.9 e	205,000	10.8		Allegheny (Kiskiminitas) and Monongahela.
1908, March 20,	27.3 e	301,000	15.8		Allegheny and Monongahela.
1909, February 17,	19.2 e	181,000	9.5		Allegheny.
1909, February 25,	22.3 e	226,000	11.9		Allegheny and Monongahela.
1909, May 2,	22.2 e	224,000	11.8		Allegheny.
1910, January 19,	22.8 e	233,000	12.3		Monongahela.
1910, March 1,	22.0 e	221,000	11.6		Allegheny.
1911, January 15,	23.8 e	248,000	13.1		Allegheny and Monongahela.
1911, January 31,	25.2 e	269,000	14.2		Monongahela.
1911, September 16,	19.7 e	188,000	9.9		Allegheny.
1912, February 27,	20.4 e	198,000	10.4		Allegheny and Monongahela (Youghiogheny).
1912, March 16,	19.0 e	178,000	9.4		Monongahela.
1912, March 22,	28.1 e	313,000	16.5		Allegheny (Kiskiminitas) and Monongahela.
1912, April 3,	20.0 e	192,000	10.1		Allegheny.
1912, July 26,	19.7 e	188,000	9.9		Monongahela.
1913, January 9,	31.3 e	364,000	19.2		Allegheny and Monongahela.
1913, January 12,	26.3 e	286,000	15.0		Allegheny and Monongahela.
1913, March 28,	30.4 e	349,000	18.4		Allegheny and Monongahela.
1913, November 17,	22.2 e	224,000	11.8		Allegheny and Monongahela.
1914, March 29,	21.2 e	209,000	11.0		Allegheny.

FLOOD DAMAGE STATISTICS

An investigation was made to ascertain the extent of monetary losses occasioned by floods. This was done at a number of towns by making a house to house canvass of the flooded districts, interviewing individual property holders either at their homes or places of business, and by viewing the damage wherever possible. The large industrial enterprises usually were able to furnish accurate figures, while for smaller properties the estimates were often approximate. The censuses in the various localities were carried out under uniform methods, the first step being the preparation of maps showing accurately the boundaries of the flooded districts. These were then subdivided into blocks or other convenient units and the damages listed for each. The census takers were persons familiar with the localities assigned to them and conversant with the nature of flood damage. The latter was classified under the following headings:

1. Cost of removing goods from danger of submergence and replacing same after the subsidence of the flood. This item covered furniture and personal effects in the case of residences, and raw or manufactured articles at industrial plants.
2. Damage to goods by water.
3. Cost of pumping water from cellars.
4. Estimated loss due to suspension of or interference with business, an item which was not always susceptible of precise treatment and for which dependence usually had to be placed on the judgment of the individuals damaged.
5. Physical damage to real estate, buildings, fences, sidewalks, etc., based on cost of repairs or replacement, but not including depreciation in land values resulting from inundation.
6. Damage to machinery.
7, 8, 9. Labor statistics, showing respectively the number of men employed immediately previous to the flood, the number thrown out of employment due to the suspension of business, and their estimated losses in wages.
10. Expense of removing debris after the flood.

Whenever available, estimates of damage sustained by municipalities and public service corporations were obtained.

The Commission selected for its investigations the Shenango and Beaver valleys, and the Allegheny Valley for the flood of March 26-28, 1913, also the Lehigh Valley for the flood of February 28, 1902, these being respectively the most destructive floods which have taken place in these sections. Flood damage statistics are also given for certain other floods.

Allegheny Valley

The results of the census in the Allegheny Valley are presented in Table No. 18, and are of interest as the flood of March 1913 was caused by the same storm which in Ohio was followed by phenomenal flood devastation. The greatest individual losses were those sustained by the Pittsburgh Plate Glass Company, which maintains plants at Ford City and Tarentum. The losses at the two plants exceeded $300,000, not including indirect business losses or those resulting from the Tarentum plant being closed for six weeks, including the loss of wages of 300 men during that period. The Tarentum plant was damaged by water from Bull Creek. A flood wall around the casting hall kept the water out of the furnaces until nearly midnight of March 26, 1913, when it broke, flooding four furnaces and kilns which contained glass, wrecking them completely. At Natrona the plants of the Allegheny Steel Company and the West Penn Steel Company sustained little damage on account of their elevation above the street. Though the water surrounding them was from 4 to 5 feet deep, none entered the buildings, and only the fly-wheel pits filled, causing the plants to shut down. At Youngsville the borough sustained damages to streets, culverts and retaining walls estimated at $1,500; and similar damage at Warren amounted to $1,575. Freeport and Tarentum reported trifling borough losses. At Meadville it was estimated that more than half of the flood damage was caused by backwater on Mill Run, a small brook emptying into French Creek at this point. The municipal damage was estimated at $10,000. Titusville reported municipal damages amounting to $8,375. The total damage in the Pittsburgh district, based on estimates made by the Pittsburgh Flood Commission for the flood of February 16, 1908, which reached a stage within 0.3 foot of that of March 28, 1913, was approximately $900,000.

On the main line of the Erie Railroad 12 miles of track were inundated, as well as 16.5 miles on its Franklin Branch between Meadville and Oil City. Traffic was interrupted on the latter branch 11 days; between Corry and Meadville, 1½ days; and between Meadville and Ohio points, 3¼ days. The total damage to road-bed and tracks amounted to $22,000, of which about $3,000 is chargeable to washouts between Shenango and Greenville, caused by Shenango River. There was no damage to bridges, and that to buildings and other structures, telegraph lines and signals amounted to less than $400. The estimated monetary loss due to loss of business in Pennsylvania was estimated at $12,000, the detouring of trains, meals for passengers and feed for stock aggregating an additional $6,000.

The Northwestern Pennsylvania Railway Company, which operates electric traction lines in Meadville and to suburban points, sustained

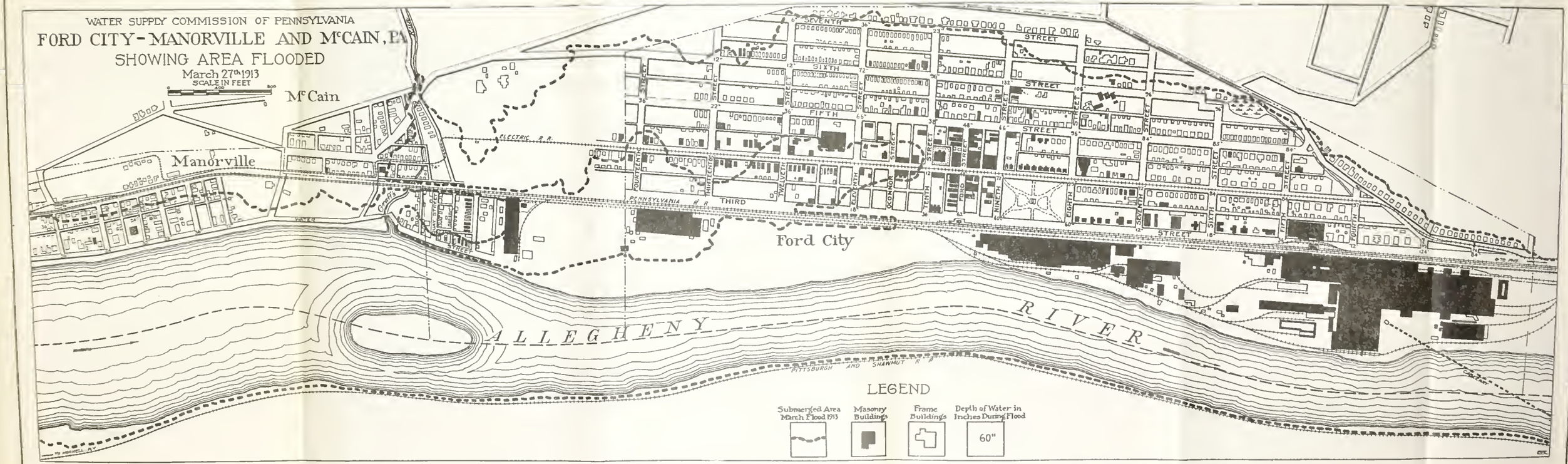
Allegheny River Flood of March 27, 1913, showing Fifth Avenue and Pennsylvania Railroad at Tarentum

damage to road-beds and track amounting to approximately $16,000, their lines being inundated in Meadville, between Venango and Saegerstown, and at other points aggregating 3 miles. Traffic was suspended for a period of 24 hours on the entire system, and parts of the street car system in Meadville were not operated for 3 days. Its estimate of damage due to interruption and loss of business is $5,000.

On the main line of the Buffalo Division of the Pennsylvania Railroad 2.25 miles of track were inundated and traffic suspended one-half day; the total damage to track, wires and one bridge being about $1,350. On its Chautauqua Branch approximately 2 miles of track were inundated and traffic suspended 24 hours, the damage sustained to tracks approximating $2,100, to bridges $1,375, and miscellaneous expenses amounting to about $200. On the Allegheny Division of the Pennsylvania Railroad no bridges were destroyed. Tracks were submerged in the vicinity of Kelly, Ford City, Brandon, Walnut Bend, Baum, Hickory, Tidioute and Dunns Eddy, resulting in the road-bed being badly washed in an unprecedentedly large number of landslides, necessitating the abandonment of all train service between Kiskiminitas Junction and Olean, N. Y., from noon March 26th until noon March 28th. The cost of repairing tracks and road-bed was approximately $46,000. The indirect damage due to interruption and loss of business was estimated at $100,000.

TABLE No. 18. *Monetary Losses to Industries and Properties at Certain Municipalities in the Allegheny River Basin, Resulting from the Flood of March 26, 27, 28, 1913*

Location.	Population.	Cost of removing and replacing goods.	Damage to goods by water.	Cost of pumping water from cellars.	Estimated loss by interference with business.	Damage to real estate, buildings, etc.	Damage to machinery.	Number of men employed previous to flood.	Number of men thrown out of employment.	Estimated loss in wages due to suspension of business.	Cost of removing debris.	Total monetary losses.
		1	2	3	4	5	6	7	8	9	10	
Warren,	11,080	$5,341	$9,294	$172	$8,945	$3,534	$1,382	872	595	$8,438	$3,519	$40,625
Youngsville,	1,406	237	295	5	89	3,341	55	24	.....	.....	332	4,354
Oil City,	15,657	2,072	24,302	500	17,615	4,985	3,657	2,250	1,017	7,184	4,151	64,466
Titusville,	8,533	733	9,925	27	12,238	19,062	1,975	994	979	6,114	4,199	54,273
Meadville,	12,780	1,634	17,808	25	3,055	6,474	200	255	154	1,094	3,942	34,232
Parker,	1,244	480	5,660	.....	2,740	2,040	435	200	188	2,170	815	14,340
Kittanning, Wickboro and Applewold,	7,386	6,931	29,095	959	34,330	18,960	1,795	415	366	1,894	3,364	97,328
Ford City, McCain and Manorville,	5,395	315	96,635	.....	54,370	79,845	1,020	2,435	2,302	36,680	6,010	274,875
Freeport, Laneville and Butler Junction,	2,248	.....	3,335	.....	20	930	50	188	3	10	1,365	5,710
Tarentum, Brackenridge, Natrona and Braeburn,	10,548	650	12,585	.....	44,935	34,465	350	3,335	3,198	33,490	3,490	129,965
Total,	76,277	$18,393	$208,934	$1,688	$178,337	$173,636	$10,919	10,968	8,802	$97,074	$31,187	$720,168


WATER SUPPLY COMMISSION OF PENNSYLVANIA
FORD CITY - MANORVILLE AND McCAIN, PA.
SHOWING AREA FLOODED
March 27th 1913
SCALE IN FEET
McCain
Manorville
ELECTRIC R.R.
PENNSYLVANIA R.R.
THIRD
FOURTEENTH
THIRTEENTH
TWELFTH
ELEVENTH
CONNOR
TENTH
FORD
NINTH
SEVENTH
SIXTH
FIFTH
STREET
Ford City
ALLEGHENY
RIVER
PITTSBURGH AND SHAWMUT R.R.
LEGEND
Submerged Area March Flood 1913
Masonry Buildings
Frame Buildings
Depth of Water in Inches During Flood
60"

Shenango and Beaver Valleys

A census of flood damage taken in these valleys after the flood of March 26, 1913, shows the following losses:

TABLE No. 19. *Summary of Monetary Losses in Shenango and Beaver Valleys, Resulting from Flood of March 26, 1913*

Greenville,	$16,350	
Sharpsville,	36,945	
Sharon and Farrell,	615,107	
Wheatland,	5,750	
West Middlesex,	67,500	
New Castle,	539,750	
Beaver Falls, New Brighton and Rochester,	197,970	
		$1,479,372
Railroads,	.....	498,869
Highway bridges,	.....	117,042
Total,	.....	$2,095,283

Classified statements of damage for Sharon, Farrell and New Castle are given in Tables Nos. 20 and 21.

TABLE No. 20. *Flood Damage at Sharon and Farrell Resulting from Flood of March 26, 1913*

Nature of Damage.	Individual damage.	Reported by 15 industries.	Total.
Cost of removing and replacing goods,	$2,320	$1,214	$3,534
Damage to goods,	159,894	.....	159,894
Estimated loss by interference with business,	51,108	43,200	94,308
Damage to real estate, buildings, etc.,	43,892	66,344	110,236
Damage to machinery,	28,261	23,068	51,329
Estimated loss in wages due to suspension of business,	16,211	107,945	124,156
Cost of removing debris,	17,254	54,396	71,650
Total,	$318,940	$296,167	$615,107

About 7,950 men, out of 9,542 employed, were thrown out of employment for an average of 5 1-3 days per man.

TABLE No. 21. Flood Damage at New Castle, Resulting from Flood of March 26, 1913

Nature of Damage.	Individual damage.	Reported by 13 industries.	Total.
Cost of removing and replacing goods,	$4,197	$3,297	$7,494
Damage to goods,	131,230	.....	131,230
Cost of pumping out cellars,	3,307	.....	3,307
Estimated loss by interference with business,	81,360	28,790	110,150
Damage to real estate, buildings, etc.,	73,978	43,305	117,283
Damage to machinery,	6,970	3,625	10,595
Estimated loss in wages due to suspension of business,	15,543	100,327	115,870
Cost of removing debris,	24,279	19,542	43,821
Total,	$340,864	$198,886	$539,750

About 6,200 men, out of 7,360 employed, were thrown out of employment for an average of nearly 6½ days per man.

Lehigh Valley

The following statement of damages resulting from the February 28, 1902, flood in the Lehigh Valley is the result of a careful canvass made at 21 municipalities. Inasmuch as the flood took place nearly 13 years ago, some difficulty was experienced in obtaining complete estimates, and in a few instances no figures could be obtained. The Lehigh Coal & Navigation Company found it impossible to estimate the damage to the canal system, for the reason that the damage inflicted by the flood of December 1901 had not been repaired at the time the February 1902 flood occurred. The Commission believes that the figures here given are, on the whole, reliable and of value in conveying a fair conception of the enormity of the damage caused by this flood, and would emphasize the fact that during the 13 years which have elapsed much additional property has been placed in the Lehigh Valley, and that, therefore, a repetition of a flood similar in magnitude to that of 1902 at the present time would be attended with vastly greater damage.

TABLE No. 22. *Monetary Losses to Municipalities, Industries and Properties in the Lehigh River Valley, Resulting from the Flood of February 28, 1902*

Location.	Population.	Cost of removing and replacing goods.	Damage to goods by water.	Cost of pumping water from cellars.	Estimated loss by interference with business.	Damage to real estate, buildings, etc.	Damage to machinery.	Number of men employed previous to flood.	Number of men thrown out of employment.	Estimated loss in wages due to suspension of business.	Cost of removing debris.	Total monetary losses.
		1	2	3	4	5	6	7	8	9	10	
White Haven,	1,438	.....	$100	.....	$75	.....	.....	50	50	$150	$15	$340
Mauch Chunk,	3,952	$45	16,590	.....	2,900	$1,700	$1,000	8	.....	.....	1,025	23,260
Lehighton,	5,316	50	9,200	$20	6,984	1,139	6,625	.....	.....	3,750	1,800	29,568
Weissport,	638	250	3,500	250	.....	5,000	500	.....	.....	.....	2,500	12,000
Bowmanstown,	.....	.....	.....	.....	.....	75	.....	.....	.....	.....	.....	75
Palmerton,	.....	.....	4,378	.....	2,000	1,700	2,000	4	.....	.....	475	10,553
Lehigh Gap,	.....	.....	3,000	.....	.....	350	.....	.....	.....	.....	50	3,400
Slatington,	4,454	.....	200	.....	.....	500	400	.....	.....	.....	.....	1,100
Walnutport,	.....	.....	1,000	.....	.....	1,500	250	.....	.....	.....	250	3,000
Laurey's,	.....	.....	.....	.....	6,000	200	200	12	.....	.....	50	6,450
Cementon,	.....	.....	.....	.....	.....	2,000	.....	.....	.....	.....	.....	2,000
Siegfried,	.....	.....	.....	.....	.....	.....	2,000	.....	.....	.....	.....	2,000
Coplay,	2,670	.....	.....	1,400	.....	.....	.....	.....	.....	.....	.....	1,400
Northampton,	8,729	190	4,500	20	200	2,700	100	31	11	40	500	8,250
Catasauqua,	5,250	215	10,825	25	2,800	825	625	1,079	1,070	7,221	740	23,276
Allentown,	51,913	1,230	199,400	1,748	53,487	45,294	27,886	5,239	3,459	52,275	13,029	394,349
Bethlehem,	12,837	355	33,650	855	3,530	7,470	6,475	510	400	3,500	8,525	64,360
South Bethlehem,	19,973	185	8,300	1,255	20,230	21,230	2,400	5,010	3,000	10,000	10,215	73,815
Shimersville,	.....	.....	125	20	7,105	20	30	80	75	600	578	8,478
Freemansburg,	867	50	7,470	227	180	690	25	8	.....	.....	1,442	10,084
Easton,	28,523	350	8,054	.....	1,750	17,335	20	.....	.....	50	52,820	80,379
Total,	146,560	$2,920	$310,292	$5,820	$107,241	$109,728	$50,536	12,031	8,065	$77,586	$94,014	$758,137

The flood of February 28, 1902, proved particularly destructive to the railroad lines and canal system in the Lehigh Valley. The Lehigh Valley Transit Company, which also now operates the Easton Transit Company, suffered a damage of about $50,000, distributed as follows:

LEHIGH VALLEY TRANSIT COMPANY

Damage to tracks,	$2,000
Damage to bridge at Hokendauqua,	6,000
Damage to equipment,	6,132
Cost of detouring over other bridges,	25,000
Total,	$39,132

EASTON TRANSIT COMPANY

Replacing road-bed from Glendon bridge to Island Park, including two trestle bridges,	$11,045
Total,	$50,177

The Lehigh Valley Railroad was inundated at various points between White Haven and Easton, and complete traffic was not restored until March 31, 1902. The monetary losses were as follows:

Damage to road-bed and tracks,	$66,271 92
Damage to bridges,	406,840 39
Damage to buildings and structures other than bridges,	176,645 05
Damage to equipment,	4,282 50
Damage to telegraph lines and signals,	3,884 34
Cost of detouring trains and other transportation expenses,	24,491 50
Estimated monetary loss due to interruption of business,	174,856 45
Engineering and superintendence,	1,324 25
Total,	$858,596 40

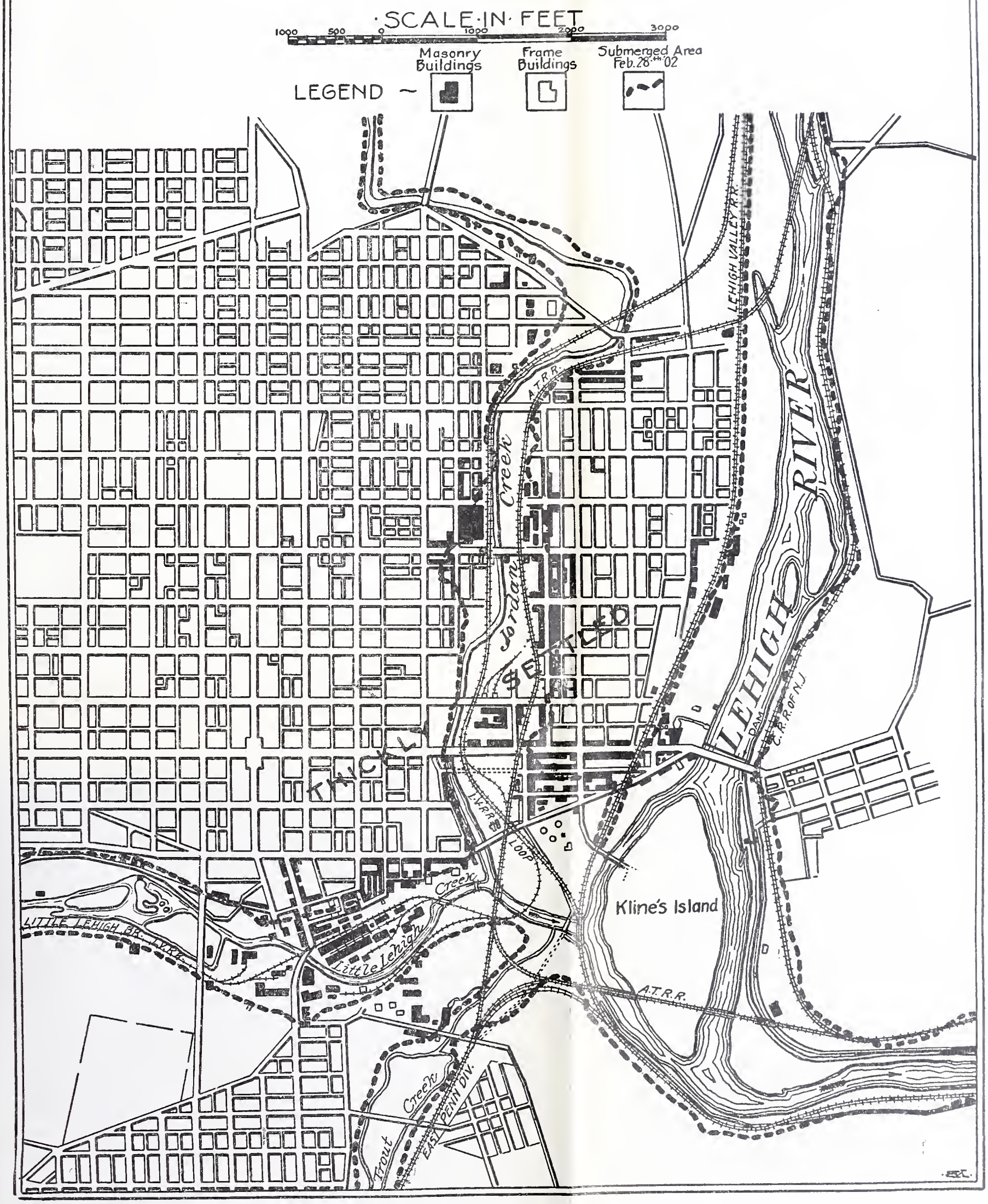
The principal damage to bridges occurred at the following points: White Haven Bridge, masonry and superstructure destroyed; Hayes Creek arch, masonry destroyed; Hickory Run Bridge, masonry destroyed and superstructure damaged; Penn Haven Bridge, masonry and superstructure destroyed; Mauch Chunk Narrows Bridge, masonry damaged. In addition to these, five smaller bridges and culverts were damaged or destroyed.

WATER SUPPLY COMMISSION OF PENNSYLVANIA

ALLENTOWN

SHOWING PRINCIPAL FLOODED DISTRICT

FEBRUARY - 28th 1902



The Central Railroad Company of New Jersey found it impossible to segregate the damage to their lines resulting from the floods of December 1901 and February 1902. The estimated aggregate damage due to both floods is placed at $900,000. The Ironton Railroad Company sustained damage to road-bed and tracks of $1,000; damage to bridges, approximately $4,000; and loss of business of approximately $700. Traffic was interrupted 36 days. The Lehigh & New England Railroad Company sustained no damage. The lines of the Bell Telephone Company and the Western Union Telegraph Company were damaged, but the amounts could not be ascertained.

Easton

In addition to the above losses in Easton in the February 1902 flood, the Commission has estimated the damage inflicted at that place by the flood of December 16, 1901, at approximately $20,000, and by the flood of October 10, 1903, at approximately $115,000, the latter, caused by the Delaware River, being the most destructive on record at that place.

Pittsburgh

The following data, in Tables Nos. 23 and 24, taken from the report of the Pittsburgh Flood Commission shows the direct losses resulting from the floods of March 15, 1907, February 16, 1908, and March 20, 1908, and the extent of overflow in the Pittsburgh district for various stages:

TABLE No. 23. *Direct Losses by Three Floods in Pittsburgh*

Classification.	Date of Flood.	Damage to buildings, equipment and machinery.	Damage to materials.	Loss to employer by suspension of business.	Loss to employees due to shut-down.	Expense of cleaning-up.	Charities dispensed and funds for prevention of disease.	Fires uncontrolled through inaccessibility or lack of water pressure.	Total.
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	
Heavy industrial,	March 15, 1907,	$180,100	$159,400	$365,400	$693,700	$79,200	.....	.....	$1,477,800
	February 16, 1908,	30,900	10,200	33,500	138,800	16,400	.....	.....	229,900
	March 20, 1908,	15,000	4,800	18,900	120,500	11,300	.....	.....	170,500
	Total,	226,000	174,500	417,800	953,000	106,900	.....	.....	1,878,200
Lesser industrial,	March 15, 1907,	50,800	320,600	82,000	58,300	62,100	.....	.....	573,800
	February 16, 1908,	5,500	12,500	22,300	7,000	19,900	.....	.....	67,200
	March 20, 1908,	3,600	5,000	7,900	4,300	6,500	.....	.....	27,300
	Total,	59,900	338,100	112,200	69,600	88,500	.....	.....	668,300
Heavy mercantile,	March 15, 1907,	186,000	706,800	867,700	137,200	108,800	.....	.....	2,006,500
	February 16, 1908,	15,000	19,200	189,700	68,400	22,900	.....	.....	315,200
	March 20, 1908,	10,100	4,500	72,500	17,300	14,000	.....	.....	118,400
	Total,	211,100	730,500	1,129,900	222,900	145,700	.....	.....	2,440,100
Lesser mercantile and dwellings,	March 15, 1907,	105,700	312,100	166,600	25,700	79,200	.....	.....	689,300
	February 16, 1908,	11,900	68,100	15,900	8,400	26,200	.....	.....	130,500
	March 20, 1908,	9,700	7,700	11,800	5,700	16,800	.....	.....	51,700
	Total,	127,300	387,900	194,300	39,800	122,200	.....	.....	871,500

Transportation, steam railroads,	March 15, 1907,	9,700	28,200	60,000	7,300	24,200	.....	.....	129,400
	February 16, 1908,	1,800	300	.....	600	6,900	.....	.....	9,600
	March 20, 1908,	1,600	100	.....	200	1,900	.....	.....	3,800
	Total,	13,100	28,600	60,000	8,100	33,000	.....	.....	142,800
Transportation, electric railroads,	March 15, 1907,	7,000	600	11,000	8,000	6,000	.....	.....	32,600
	February 16, 1908,	1,000	300	3,200	500	3,900	.....	.....	8,900
	March 20, 1908,	.....	200	200	300	2,600	.....	.....	3,300
	Total,	8,000	1,100	14,400	8,800	12,500	.....	.....	44,800
Navigation,	March 15, 1907,	34,100	6,200	15,100	2,400	1,000	.....	.....	58,800
	February 16, 1908,	8,500	1,600	6,200	1,700	800	.....	.....	18,800
	March 20, 1908,	1,500	900	4,000	700	400	.....	.....	7,500
	Total,	44,100	8,700	25,300	4,800	2,200	.....	.....	85,100
Interests not classified,	March 15, 1907,	42,900	11,700	10,600	500	6,100	.....	.....	71,800
	February 16, 1908,	21,700	1,000	9,000	800	2,500	.....	.....	35,000
	March 20, 1908,	4,100	1,000	700	.....	2,100	.....	.....	7,900
	Total,	68,700	13,700	20,300	1,300	10,700	.....	.....	114,700
City departments,	March 15, 1907,	12,200	5,800	.....	.....	16,800	$9,700	$175,000	219,500
	February 16, 1908,	6,000	5,000	.....	.....	4,500	9,200	.....	24,700
	March 20, 1908,	6,000	5,000	.....	.....	4,400	8,900	.....	24,300
	Total,	24,200	15,800	.....	.....	25,700	27,800	175,000	268,500
Summary,	March 15, 1907,	628,500	1,551,400	1,578,400	933,100	383,400	9,700	175,000	5,259,500
	February 16, 1908,	102,300	118,300	279,800	226,200	104,000	9,200	.....	839,800
	March 20, 1908,	51,600	29,200	116,000	149,000	60,000	8,900	.....	414,700
	Total,	$782,400	$1,698,900	$1,974,200	$1,308,300	$547,400	$27,800	$175,000	$6,514,000

TABLE No. 24. *Overflow in Pittsburgh District at Various Flood Stages*

Classification.	25-foot stage.	Flood of Mar. 20, 1908. 27.3-foot stage.	Flood of Feb. 16, 1908. 30.7-foot stage.	Flood of Mar. 15, 1907. 35.5-foot stage.	Assumed 40-foot stage.
Acres of land submerged,	115	230	670	1,540	1,850
Miles of main railroad tracks submerged,	1.15	1.4	8.2	17	23
Miles of street car tracks submerged,	0.55	1.3	4.8	8.7	13
Miles of streets and alleys submerged,	1.5	6.3	16.3	33.4	45

Westmoor

A census of damage was taken at Westmoor, situated on the flats opposite Wilkes-Barre, after the flood of March 29, 1914, which covered the streets to a depth of 3.5 feet, the result of which is as follows:

Cost of removing and replacing goods,	$840	
Damage to goods,	263	
Cost of pumping water from cellars,	227	
Estimated loss by interference with business,	625	
Damage to real estate, buildings, etc.,	5,849	
Estimated loss in wages due to suspension of business,	2,865	
Cost of removing debris,	1,686	
Total,		$12,355
Losses to two contracting firms, including loss of time to employes,		14,500
Total,		$26,855

The census of Westmoor is of interest inasmuch as it is a residential district, containing 338 residences, 4 business houses, 1 church, 1 school and no industries.

York

An estimate has been made of flood damage at York resulting from the flood of June 26, 1884, which was the most disastrous one in the history of that city. Detailed individual losses were ascertained at that time and published in the York Evening Dispatch and Record showing a total property damage amounting to nearly $260,000. In addition to this, all bridges over Codorus Creek in York and at numerous points in the county were swept away. The cost to the County of replacing these bridges was covered by a bond issue of $100,000.

Juniata River Flood of June 1, 1889, at Lewistown

Flood of June 1889

The Commission has found it impossible to obtain reliable estimates of the damage which resulted from the flood of June 1, 1889. The only figures which warrant publishing are the following:

Statistics compiled under the direction of S. C. Long, General Superintendent for the Pennsylvania Railroad Company, show an approximate total loss to that Company of over $5,000,000, which does not include the indirect losses on account of suspension of traffic and diversion of passengers and freight over other lines. Traffic was interrupted on the main line between Philadelphia and Pittsburgh for about 14 days; Harrisburg and Renovo, 7 days; Williamsport and Elmira, N. Y., 14 days; and Harrisburg and York, 2 days. Tracks were damaged or destroyed as follows:

	Damaged.	Destroyed.
Philadelphia to Pittsburgh (main line),	*.....	*10.0 Miles
Elmira Division,	7.79 Miles	3.18 "
Baltimore Division,	.03 "	.03 "
Summit Branch Railroad,	.....	.07 "
Williamsport Division,	3.00 "	2.30 "
Ridgway & Clearfield Railroad, Susquehanna & Clearfield Railroad, Lewisburg & Tyrone Railroad,	19.19 "	7.07 "

*In the vicinity of Johnstown. No data available for other portions of main line.

The number of bridges damaged or destroyed was as follows:

Pittsburgh Division,	3
Middle Division,	18
Cresson Division,	2
Philadelphia Division,	1
Old Frederick Division,	4
Sunbury & Lewistown Railway,	8
Mifflin & Center County Railroad,	10
Bedford Division,	11
Tyrone Division,	5
Tyrone & Clearfield Railway,	5
Bald Eagle Valley Railroad,	4
Lewisburg & Tyrone Railroad,	5
Old Altoona Division,	21
Conemaugh Division,	7
Elmira Division,	26
Baltimore Division,	1
Shamokin Division,	16
Williamsport Division,	14
Ridgway & Clearfield Railroad, Susquehanna & Clearfield Railroad,	21

The necessary repairs covered periods varying from a few months to one and one-half years.

Similar estimates were made by the Philadelphia & Reading Railway Company, showing an aggregate loss of $439,000, which does not include indirect damage consequent upon 4 or 5 days interruption of traffic.

The greatest losses in one locality occurred at Johnstown, a large part of which was wiped out, causing the loss of about 2,280 lives. The complete monetary losses will never be known, but it is believed that in addition to those sustained by the Pennsylvania Railroad,

and which are included in the foregoing statement, they amounted to about $3,000,000. This flood did not seriously affect the main Allegheny River, the precipitation being heavy on the headwaters only. The resulting stage at Pittsburgh was 24.0 feet, and caused but trifling damage. The brunt of the storm was borne by the valleys of the Juniata and West Branch Susquehanna rivers, the damage there being without parallel in the history of the State.

The destruction of the Pennsylvania Canals was so general as to become the initial cause of their abandonment. For further information on this subject the reader is referred to Part IX, on Navigation.

Scranton and Roaring Brook Valley

The following statement shows the damage sustained at Scranton and vicinity as a result of the flood on Roaring Brook July 10, 1914. Most of the figures represent actual expenditures made in repairs, and in only a few cases was it necessary to use estimates where repairs had not been completed:

CITY OF SCRANTON

Damage to bridges,	$30,250 00	
Cleaning and pumping out 125 cellars and basements,	200 00	
		$30,450 00

THE SCRANTON GAS & WATER COMPANY

Damage to pipe lines,	$12,224 84	
Damage to reservoirs,	2,979 94	
Damage to bridges,	2,621 64	
Cleaning reservoirs and weirs,	2,520 00	
Damage to crops, roads and other property,	2,587 82	
		$22,934 24

OLYPHANT WATER COMPANY

Damage to pipe lines,	$602 60	
Damage to reservoirs,	50 00	
		$652 60

THE DELAWARE, LACKAWANNA & WESTERN RAILROAD COMPANY

Damage to road-bed and tracks,	$56,850 00	
Damage to bridge east of Scranton,	4,560 87	
Culvert east of Moscow Station,	18,671 78	
Damage to buildings and structures other than bridges,	150 00	
Damage to two steel hopper cars,	2.8 67	
Damage to telegraph lines and signals,	1,874 61	
Cost of detouring trains,	12,644 00	
Expense of additional crews, train service, protection of perishable shipments and live stock,	3,100 00	
		$98,089 93

The monetary loss due to interruption of traffic and loss of business has not been estimated. Two and six-tenth miles of track were inundated and an aggregate of 13.6 miles were affected by the storm. Traffic was suspended from 4 p. m. July 10th to 1 p. m. July 13th.

Roaring Brook at Dunmore, showing Erie Railroad Embankment after Flood of July 10, 1914

THE DELAWARE & HUDSON COMPANY

Damage to road-bed, tracks and one bridge,	$11,235 00	
Cost of detouring trains,	125 00	
Monetary loss due to 9 hours interruption of business,	640 00	
		$12,000 00

ERIE RAILROAD COMPANY

Damage to road-bed and tracks,	$33,120 00	
Damage to bridges,	6,607 00	
Damage to buildings and structures other than bridges,	5,555 00	
Damage to equipment,	257 00	
Damage to telegraph lines and signals,	100 00	
Monetary loss due to interruption of business,	17,503 78	
Cost of detouring trains,	1,614 00	
		$64,756 78

Twenty miles of track were inundated and traffic was suspended for 67 hours.

LACKAWANNA & WYOMING VALLEY RAILROAD COMPANY

Damage to road-bed and tracks,	$150 00	
Damage to power plant,	500 00	
Repairing wing wall of dam,	700 00	
		$1,350 00
Total,		$230,233 55

The above statement does not include private losses in Scranton and those inflicted to crops in the adjacent country. Neither does it include the losses sustained by the County due to washing out of bridges and county roads. It is understood, however, that the two latter items were not large amounts.

State Expenditures for Rebuilding County Bridges

Since 1897 the Commonwealth has expended large sums of money in rebuilding county bridges which have been destroyed by floods. The Act under which this work is done was approved June 3, 1895, and amended April 21, 1903. To date, nearly $3,400,000, as shown in Tables Nos. 25 and 26, has been paid by the State under this provision, presenting a forceful argument in favor of participation by the Commonwealth in measures for flood reduction.

TABLE No. 25. *State Expenditures for Rebuilding County Bridges Destroyed by Floods*

Year.	Amount.
1897,	$83,300
1898,	9,500
1900,	36,750
1901,	26,810
1902,	966,150
1903,	68,300
1904,	1,033,831
1905,	527,065
1906,	105,994
1907-8,	355,281
1909-10,	18,775
1913-14,	59,688

TABLE No. 26. *State Expenditures for Rebuilding County Bridges Destroyed by Floods, Classified by Rivers*

Delaware River above Easton, all on tributaries,		$213,700
Lehigh River, all on main river,		357,700
Schuylkill River, all on main river,		38,700
Susquehanna River,		
North Branch and tributaries,	$1,503,785	
West Branch and tributaries,	234,702	
Juniata River and tributaries,	177,700	
Tributaries to main stream,	296,975	
		2,213,162
Allegheny River, main stream,	$129,500	
Clarion River,	36,700	
Kiskiminitas River,	131,194	
Mahoning River,	11,995	
		309,389
Monongahela River,		None
Ohio River,		None
Beaver River, main stream,	$107,800	
Shenango River,	71,393	
Connoquenessing Creek,	81,300	
		260,493
Total,		$3,393,144

TOWNS SUBJECT TO DAMAGE BY FLOODS

In Table No. 27 are listed, by streams, 159 of the principal towns in Pennsylvania which are subject to damage by floods. The column headed "Serious Damage" contains the names of towns frequently inundated and where flood damage assumes large proportions. In the column headed "Minor Damage" are those which suffer only from extraordinary floods, occurring at long intervals, and where on the whole flood damage is of minor importance. The table shows that only 44 towns suffer serious damage and that they are as a rule grouped within restricted areas, principally along the Lehigh River; North Branch Susquehanna River, in the Wyoming Valley; West Branch Susquehanna River; Turtle Creek, and the Shenango and Beaver rivers.

TABLE No. 27. *List of Towns Subject to Damage by Floods*

Stream.	Drainage Basin.	Location.	
		Serious Damage.	Minor Damage.
Lackawaxen River,	Delaware,	Honesdale,	Hawley.
Brodheads Creek,	Delaware,		Stroudsburg.
Lehigh River,	Delaware,	Mauch Chunk,	
		Lehighton,	Weissport.
			Palmerton.
			Northampton.
		Catasauqua.	
		Allentown.	
		Bethlehem.	
		South Bethlehem,	Shimersville.
			Freemansburg.
		Easton.	
Delaware River,	Delaware,		New Hope.
			Bristol.
Little Schuylkill River,	Delaware,		Tamaqua.
Schuylkill River,	Delaware,		Pottsville.

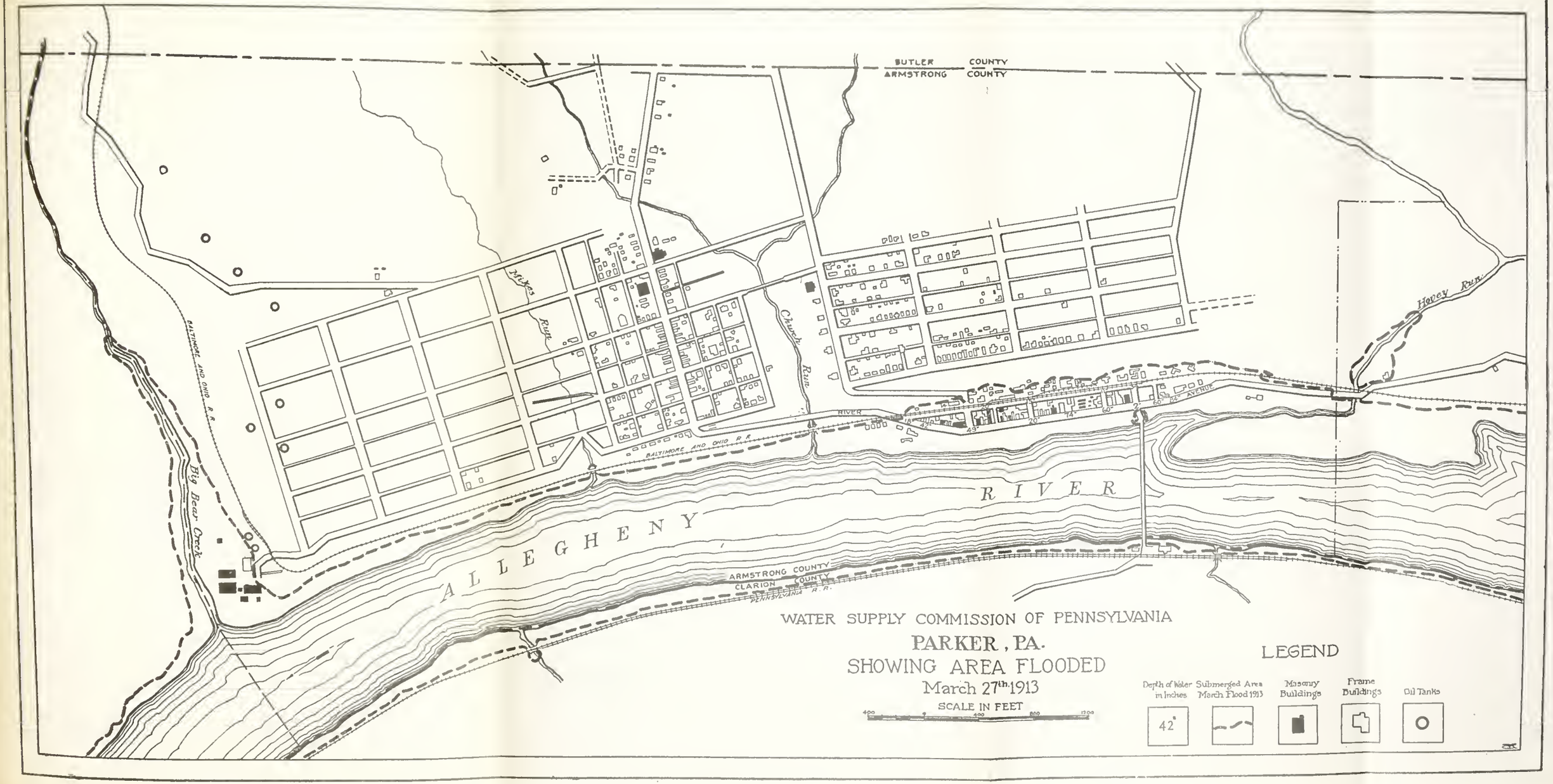

BUTLER COUNTY
ARMSTRONG COUNTY
Mikes Run
Church Run
Honey Run
BALTIMORE AND OHIO R.R.
Big Bear Creek
RIVER
ALLEGHENY
ARMSTRONG COUNTY
CLARION COUNTY
PENNSYLVANIA R.R.
60' 42nd AVENUE
42'
49'
20'
74'
60'
WATER SUPPLY COMMISSION OF PENNSYLVANIA
PARKER, PA.
SHOWING AREA FLOODED
March 27th 1913
SCALE IN FEET
400 0 400 800 1200
LEGEND
Depth of Water in Inches
Submerged Area March Flood 1913
Masonry Buildings
Frame Buildings
Oil Tanks
42'

TABLE No. 27—Continued

Stream.	Drainage Basin.	Location.	
		Serious Damage.	Minor Damage.
			Port Clinton.
			Hamburg.
			Reading.
			Pottstown.
			Royersford.
			Phoenixville.
			Norristown.
			Bridgeport.
			Conshohocken.
		Manayunk.	
Brandywine Creek, ...	Delaware, ...	.....	Coatesville.
North Branch Susquehanna River.	Susquehanna, ...	.....	Great Bend.
			Towanda.
			Tunkhannock.
		West Pittston.	
		Dorranceton.	
		Wilkes-Barre.	
		Kingston.	
		Plymouth, ...	West Nanticoke.
			Berwick.
			Bloomsburg.
			Catawissa.
			Danville.
Lackawanna River, ...	Susquehanna, ...	.....	Olyphant.
			Scranton.
West Branch Susquehanna River.	Susquehanna, ...	.....	Mehaffey.
			Clearfield.
			Renovo.
		Lock Haven.	
		Jersey Shore.	
		Williamsport, ...	Muncy.
			Montgomery.
			Watsontown.
		Milton, ...	Lewisburg.
			Northumberland.
Moshannon Creek, ...	Susquehanna, ...	.....	Philipsburg.
Susquehanna River, ...	Susquehanna, ...	.....	Sunbury.
			Selinsgrove.
			Duncannon.
			Harrisburg.
			Steelton.
		Middletown.	
		Royalton, ...	Marietta.
			Columbia.
			Wrightsville.
Little Juniata River, ..	Susquehanna, ...	.....	Tyrone.
Frankstown Br. Juniata River.	Susquehanna, ...	.....	Williamsburg.
			Huntingdon.
Raystown Br. Juniata River.	Susquehanna, ...	.....	Everett.
			Saxton.
Juniata River, ...	Susquehanna, ...	.....	Lewistown.
			Mifflin.
			Mifflintown.
			Newport.
Codorus Creek, ...	Susquehanna, ...	York.	
Conococheague Creek, ..	Potomac, ...	.....	Chambersburg.
Kinzua Creek, ...	Ohio, ...	.....	Kinzua.
Allegheny River, ...	Ohio, ...	Warren, ...	Tidioute.
		Oil City, ...	Franklin.
			Parker.
			Kittanning.
		Ford City, ...	Freeport.
			Natrona.
			Brackenridge.
			Tarentum.
			New Kensington.
			Oakmont.
		Sharpsburg.	
		Etna.	
Brokenstraw Creek, ...	Ohio, ...	.....	Garland.
			Youngsville.
Tionesta Creek, ...	Ohio, ...	.....	Tionesta.
Oil Creek, ...	Ohio, ...	.....	Titusville.
			Rouseville.
French Creek, ...	Ohio, ...	.....	Union City.
			Cambridge Springs
			Saegerstown.
		Meadville, ...	Cochranton.
Sandy Creek, ...	Ohio, ...	Sandy Lake.	
Clarion River, ...	Ohio, ...	.....	Ridgway.
Red Bank Creek, ...	Ohio, ...	.....	Brookville.
			New Bethlehem.
Stony Creek, ...	Ohio, ...	Johnstown.	

TABLE No. 27—Continued

Stream.	Drainage Basin.	Location.	
		Serious Damage.	Minor Damage.
Kiskiminitas River, ...	Ohio, ...	.....	Saltsburg. Avonmore. Apollo. Vandergrift. Leechburg.
Monongahela River, ...	Ohio, ...	.....	Point Marion. Brownsville. California. Fayette City. Belle Vernon. Charleroi. Monessen. Donora. Monongahela.
		McKeesport, ...	Duquesne. Braddock. Homestead.
		Pittsburgh.	
Redstone Creek, ...	Ohio, ...	.....	Uniontown.
Youghiogheny River, ..	Ohio, ...	Confluence, ...	Connellsville. West Newton.
Turtle Creek, ...	Ohio, ...	Wilmerding. Turtle Creek. East Pittsburgh.	
Ohio River, ...	Ohio, ...	.....	McKees Rocks. Coraopolis. Ambridge. Aliquippa. Freedom. Rochester. Beaver.
Shenango River, ...	Ohio, ...	.....	Jamestown. Greenville.
		Sharpsville. Sharon. Farrell. Wheatland. West Middlesex. New Castle.	
Beaver River, ...	Ohio, ...	.....	West Pittsburgh.
		Beaver Falls. New Brighton, ... West Bridgewater.	Fallston.
Connoquenessing Creek,.	Ohio, ...	.....	Butler. Ellwood City.
Mill Creek, ...	Erie, ...	.....	Erie.

Commonwealth of Pennsylvania

WATER SUPPLY COMMISSION OF PENNSYLVANIA

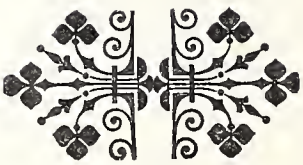
Water Resources Inventory Report

PART IX

NAVIGATION

ACT OF JULY 25, 1913

HARRISBURG, PA.
WM. STANLEY RAY, STATE PRINTER
1916



WATER SUPPLY COMMISSION OF PENNSYLVANIA

Chairman

*JOHN BIRKINBINE, Cynwyd, Montgomery County
(Died May 14, 1915)

Vice Chairman

**BENJAMIN K. FOCHT, Lewisburg, Union County
(Resigned February 28, 1915)

Secretary

THOMAS J. LYNCH, South Bethlehem, Northampton County

Commissioner of Forestry

ROBERT S. CONKLIN, Columbia, Lancaster County

Commissioner of Health

DR. SAMUEL G. DIXON, Ardmore, Montgomery County

---

*ROBERT A. ZENTMYER, Tyrone, Blair County
(Appointed August 23, 1915, vice John Birkinbine, Deceased)

**OLIVER S. KELSEY, Flemington, Clinton County
(Appointed December 1, 1915, vice Benjamin K. Focht, Resigned)

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LETTER OF TRANSMITTAL

Office of the Water Supply Commission,

Harrisburg, September 20, 1916.

His Excellency, the Governor of the Commonwealth of Pennsylvania:

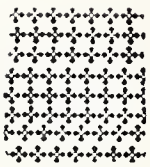
The Members of the Senate and the House of Representatives of the Commonwealth of Pennsylvania:

Gentlemen: The Water Supply Commission of Pennsylvania respectfully submits herewith Part IX of the Water Resources Inventory Report, entitled "Navigation."

THE WATER SUPPLY COMMISSION OF PENNSYLVANIA,

THOMAS J. LYNCH,

Secretary.



PART IX

NAVIGATION

(The data herein contained were collected during the year 1914, and the conditions described were those then existing)

CHAPTER I

INTRODUCTION

The rivers of Pennsylvania, once the most important means of transportation, are today an insignificant factor in the performance of this work. These natural avenues of trade were first used for the transportation of immigrants and their belongings. They were developed later by canals and improved channels, through state and corporate enterprises, into an extensive system, and prior to the building of railroads afforded the principal means of transportation.

The history of navigation on the streams of Pennsylvania may be divided into three periods: 1st, that before river improvements were made, extending from the time of early settlements to the close of the first quarter of the 19th century; 2d, that of canal and slack-water transportation developed by the state and by corporations, covering the 2d and 3d quarters of the 19th century, and closing with the acquisition and operation of the state works by railroad companies; 3d, that of deterioration and abandonment of the state canals and of improved navigation by the Federal Government, and extending from the close of the canal period to the present time.

It is the purpose of this report to show the evolution of navigation during these periods, describing the routes, methods of transportation, volume of traffic, success of the various forms of navigation, the subsequent decadence of the early works and the causes thereof, and to point out the possibilities of future development necessary to meet the constantly increasing demands of modern commerce.

Pennsylvania occupies a strategic commercial position by reason of her richness in mineral and agricultural resources, and because of her situation upon both slopes of the Appalachian divide; on the one side touching the Atlantic and on the other reaching to the headwaters of navigation in the Mississippi Valley. These natural

advantages, coupled with the wise policy of her founders, attracted a progressive people whose energies were early applied to the improvement of the natural waterways, these being subsequently connected by navigable canals. In the effort to maintain commercial and industrial supremacy the State developed a system of canals and slackwater navigation exceeding in mileage that of any other state in the Union.

The growth and development of any community is dependent upon its transportation facilities. As a result of the early realization of this fact, New York and Pennsylvania have held first and second rank in population since 1820-30, at which time their extensive transportation systems were undertaken. Prior to the opening of the all water connection between the Eastern Seaboard and the Great Lakes via the Hudson River and the Erie Canal in 1825, Philadelphia held the commercial supremacy among the cities of the Union. The fear of losing her trade with the rapidly growing west was what decided affirmatively the long debated question of connecting the Delaware with the Ohio by a system of state-built waterways and railways.

The right to develop and use its waterways is vital to the welfare of any people, yet it has given rise to many conflicting opinions as to the best policy and the jurisdiction which should control the works, and these have resulted in injurious competition, ruinous rivalries and consequent retardation of development. Present tendencies in the development of water traffic facilities are in the direction of co-operation between the federal, state and county or local governments. If these tendencies become fixed policies it is certain that a state or community which is unwilling to assist in the improvement of its own waterways, but relies upon the hope that private capital or the Federal Government alone will afford it the needed facilities, must expect to languish and retrograde. In New York the increase in population between 1810 and 1816 was but 3,600, made up of immigrants taking the places of those who had gone "west." This westward movement gave a new impetus to internal improvements and renewed the interest in communications by roads, canals and rivers constructed or improved under state appropriations. Under individual, corporate and state enterprise the waterways were rapidly improved, and the states vied to retain their population and traffic as a source of prosperity and a means of revenue.

The policy prevailing in the early days was that "what individual enterprise could effect alone, was to be left to individual enterprise; what a state or individuals could achieve together was left to the joint action of states and individuals, but what neither of these

separately or conjoined were able to accomplish, that and that only was the province of the Federal Government." This simple aphorism has been endorsed by Lincoln, as follows: "Let the Nation take hold of the larger works and the states the smaller ones—and thus working in a meeting direction, discreetly, but steadily and firmly, what is made unequal in one place may be equalized in another, extravagance avoided and the whole country put on that career of prosperity which shall correspond with its extent of territory and the intelligence and enterprise of its people." Prior to the Civil War this was the recognized policy and the states were actively cooperating in the opening up of local resources and of lines of transportation for the public welfare.

Of the resources of the Commonwealth, the most abundant at first were the forest products, which were utilized for fuel and structural purposes and were carried chiefly by rafting during the early spring. The discovery of seemingly inexhaustible deposits of anthracite and bituminous coal gave impetus to the improvement of rivers and canals. This was followed by the development of agricultural and manufacturing industries,—oil, coke, glass, salt and cement assisting to swell the tonnage necessitated by the increase and dispersion of population demanding the necessaries of life.

Prior to the construction of railroads the only known means of transit were with beasts of burden or land vehicles, or with boats or canoes; the former required costly construction and a large expenditure of animal power to overcome the roughness and steepness of the way; the latter descending the streams by gravity or, where possible, driven by wind, were guided by oars or rudders and were poled or paddled when moving up stream. The relative utility of these systems may be compared by noting the average cost of transporting one ton one mile, where the ratio of cost is fifty to one in favor of the waterway over a well macadamized road; that is, at a given cost merchandise can be carried by water fifty times as far as on a level road, or the capacity of the carrier may be increased fiftyfold for the same distance and power. A horse with substantially the same effort may carry one person on his back, four or five on wheels, or a hundred or more on a canal boat. Or, to state the same thing in terms of burden, he may carry 200 pounds on his back, a ton on wheels, or 100 tons on a canal boat. These physical conditions led to improvement of the streams for access to the markets from the isolated habitations on the frontiers, and by means of knowledge gained from Indians, trappers and explorers, the early settlers sought the best portages whereby to cross the divides between the principal tributaries of the navigable streams. Prior to 1828, 265 companies were incorporated in Pennsylvania for internal

improvements of all kinds, including canals, rivers, turnpikes, railways and bridges, and $22,010,554 had been expended up to that time, while the works then under contract and extending to 1831 amounted to $12,450,000 or more, giving a total of $34,468,554. A report of the canal commissioners for 1833 showed a total canal mileage of 711½ then constructed or under contract. This work went on vigorously until 1840, when a change in the state administration led to its discontinuance.

CHAPTER II

EARLY NAVIGATION PRIOR TO RIVER IMPROVEMENT

When America was discovered it was in a pristine condition, and several centuries elapsed before population had established centers of industry and wealth sufficient to make it possible to improve the means of intercommunication. The streams were the natural lines of least resistance and the down flowing waters afforded the motive power; therefore they were used as the most convenient routes, while the lowest passes in the dividing ridges were sought for portage, across which trails were blazed by early explorers and trappers.

In skirting the coasts, the early navigators found a terra incognita with no charts or well defined landmarks to determine their position, but the principal bays and rivers were soon entered, named and claimed by the expeditions fitted out by Great Britain, France, Spain, Holland, Denmark, Germany and Scandinavia. The Hudson River was discovered by Hendrick Hudson in 1609, and on the same voyage he entered what is now known as Delaware Bay, but finding shoal water he made no settlement there. The following year Capt. Samuel Argall of England named it after Lord De La Ware, Governor of Virginia, but it was left for Cornelius Hendrickson to explore in 1616 when he sailed over 100 miles up the river. On his return he discovered the mouth of the Schuylkill, which means "hidden stream," its name being most applicable.

In 1643, 39 years prior to William Penn's arrival at "The Great Law" at Chester, Governor Pruitz established at Tinicum Island, just below the mouth of the Schuylkill, a settlement, which was the first permanent occupation within the limits of the present Commonwealth. The fundamental idea of Penn in the establishment of his "Holy Experiment" was to "seek out a spot on the Delaware River where it was most navigable, high, dry and healthy, where ships may best unload without lightering and where there is good soyle for provisions." Before the close of 1682, 23 ships had arrived in Pennsylvania with more than 2,000 immigrants.

Prior to the coming of the white race to these shores the rivers were used by the Indians, who traveled by canoes hollowed from logs or made from the bark of trees. Then came light tonnage sailing vessels from the old world bringing knowledge of other forms of boats, such as rafts, skiffs, arks, flatboats, yawls, ships, etc., which

soon appeared on the waters of the Delaware and other rivers. The epoch of natural open water transportation may be said to cover the period from the discovery of the rivers to the close of the War of 1812. Even before the latter date efforts had been made to organize capital and build, by artificial means, ways along and connecting the various rivers, with the right to charge tolls. These were under state charters, but in general were premature, as the necessary capital could not be obtained. Most of the early boats were built and owned by private parties, and no transportation companies for general traffic on schedules existed until after canals had come into use.

DELAWARE RIVER

The Delaware River, whose mouth is a broad estuary of the Atlantic, was early used as a means of internal communication. This waterway became an important avenue of trade as far up as Trenton, thirty miles above Philadelphia, where falls obstruct its channel, thus bringing settlers to Philadelphia, Chester and other early communities in Delaware, Pennsylvania and New Jersey (ocean going vessels being able to ascend the river as far as Philadelphia, and some to a point a number of miles beyond). As time passed this river became busy with many forms of craft, handling the traffic between the settlements on its banks and also with foreign parts.

Above Trenton the river was used to float log rafts from the upstream forests to the mills below. The first raft to navigate the Delaware is said to have started at Cochecton, some forty miles above Port Jervis, in 1746. The hazardous run brought the two adventurers who piloted it to Philadelphia, where they were given the freedom of the city. The logs that formed this raft were used as masts for ships then building in Philadelphia. Flat bottom boats of shallow draft were in use between the Delaware Water Gap and Trenton as early as 1758, and a forerunner of the modern canal barge was devised about 1770 for transporting pig iron from the Durham Furnace to tidewater. About this time a passage was effected around the Trenton Falls for rafts and small boats, the cost being given as $3,750. Water borne commerce on the river between Trenton and Easton, except logging, practically ceased with the completion, in 1832, of the Delaware Canal, connecting Easton and Bristol. It is recorded, however, that during the summer of 1852 a steamboat 150 feet long ran between Lambertville and Easton.

The heaviest water traffic was, and has always been, that between Philadelphia and the sea. While this channel is mainly outside of Pennsylvania jurisdiction, the commerce using it is almost entirely to and from Pennsylvania. The Federal Government, to keep pace with the increasing draft of ocean going vessels, has been gradually deepening the channel by dredging operations.

On the upper Delaware, long boats known as arks were employed for downstream traffic. These were 80x16 feet, drew two feet of water, and had a capacity of about 50 tons. Seven days were required to make a trip from the upper Delaware to tidewater, at a cost, with a crew of four men, of about $50. The risks were so great that only about two-thirds of the boats completed the journey in safety. Durham boats, which were also used on the Delaware, were 60 feet long, 8 to 10 feet wide, and 5 feet deep, drawing 20 inches when laden to 15 tons. The pointed ends were covered with decks which were connected along the gunwales by "running boards." These boats carried a mast with two sails and had a crew of five. When used as ferries they were sometimes moved by horse treadmill and known as "team boats," one of which plied between Bristol and Burlington in 1829.

TRIBUTARIES OF THE DELAWARE RIVER

Before canalization the Lackawaxen, Lehigh and Schuylkill rivers were used extensively for rafting, as they drained regions rich in forests. These three streams drain east, southeast and south, respectively, from the anthracite fields, and were the chief means by which this mineral first found a market. The first two streams were steep, with rocky beds, so that navigation in their natural state was hazardous and unprofitable. Some of the first river improvement work undertaken in Pennsylvania was the removal of rocks in the Lehigh. These rivers were declared public highways by Act of Assembly in 1771, at which time public subscriptions were made toward the improvement of navigation on the Lehigh, these funds being expended by a commission appointed by the Legislature, and in 1791 the Legislature appropriated $5,000 to improve navigation on the Lehigh as far above the mouth as the money would permit; but neither expenditure accomplished valuable results.

The Lehigh River boats were operated during low stages, by storing water behind flash-dams and suddenly releasing it when many loaded arks had gathered for the trip. In 1826, 3,128 tons

and in 1831, 41,000 tons of coal were thus transported. The first experiment in carrying coal down the Lehigh by arks to Philadelphia cost $14 per ton, of which $4 was for hauling it nine miles by wagon road from the mine to the river, or 44c per ton mile, as compared with about 3 mills which it now costs to haul it by railroad. The arks and flatboats were used for downstream traffic only, and at the end of the trip were broken up and sold as lumber, the crew walking back. The Durham boats were propelled usually by two men on either side of the bow thrusting poles into the river bottom and walking to the stern, pushing the boat forward as they went, this method of propulsion being similar to that employed on the "keel boats" later so popular on the Ohio and other western rivers. Shipping coal down the Lehigh was accompanied with great hardships and hazard before the river was canalized, and the traffic was several times temporarily abandoned, to be revived by a new form of navigation. The Legislature passed acts in 1771, 1791, 1794, 1798, 1810, 1814 and 1816 for the improvement of navigation on the Lehigh River. Under one of these acts a company expended over $20,000 in clearing out channels, only to abandon them later.

SUSQUEHANNA RIVER

Before canalization the Susquehanna River was a less important stream than the Delaware and its tributaries, although a considerable business flourished for a time in logging, fishing, and in the use of boats which transported coal from the Wyoming Valley on the North Branch. In 1775-6 several boat loads of anthracite shipped from Wilkes-Barre to Carlisle were the beginning of coal shipping from the Wyoming Valley. This coal was carried in arks 90 feet long, 16 feet wide, and 4 feet deep, with a capacity of 60 tons. The rapids below Columbia obstructed safe passage to the sea, while the shallowness and recurring riffles precluded the use of boats of considerable burden except during relatively short periods. The Susquehanna River ferries were always an important institution and at their sites Columbia, Wrightsville, Middletown, Harrisburg and other towns have grown up.

In 1824 it was reported to be feasible to adapt the river to ascending navigation from tidewater "if the expense of it does not prevent," but the rapid current was always a hindrance to upstream progress. One authority stated, "Nothing is now wanting as far downward

as the Conowingo Falls, even from the head of Otsego Lake, in the heart of New York State, except occasionally, at certain points, deeper water, which can be obtained by contracting the channel and clearing it of a few obstructing rocks."

Although little real effort was expended to improve navigation during the first quarter of the 19th century, or up to the time of the construction of the Susquehanna Canal, the growth of population and consequent tonnage increased along the river even prior to the completion of the Chesapeake and Delaware Canal in 1829. The record of the traffic which passed Columbia between March 3d and July 3d, 1826, four months, was:

1,037 arks
164 keel boats
1,090 rafts

Between February 28th and June 23d, 1827, four months, it was:

1,370 arks
300 keel boats
1,631 rafts

This traffic was estimated to consist of 40,775,000 feet of lumber, 11,000 tons of coal, 468,000 barrels of flour and whiskey, and 270,000 bushels of wheat, all carried over the difficult and dangerous portion of the stream from Lock Haven to tide at Port Deposit, Md., and thence transhipped by bay craft to Baltimore.

Many early settlers reached their homes on the headwaters of the Susquehanna by poling their families and goods upstream in canoes and frequently made 25 miles a day with a load of one ton.

Navigation on the Susquehanna received an impetus in 1797 by the construction of a canal 2¼ miles long around the dangerous Conewago Falls, 15 miles below Harrisburg and 60 miles above Port Deposit. This canal overcame a lift of 21 feet, by three locks and one guard lock, each 110 feet long and 18 feet wide. Two dams, 500 feet and 800 feet long respectively, were also a part of this project. This was the first canal constructed in Pennsylvania.

During the Revolution small boats for General Sullivan's army were built and a commisssary depot established at Middletown, at the mouth of Swatara Creek, 9 miles below Harrisburg. After the war, river trade at Middletown flourished until 1796, when it gradually declined until the opening of the Union Canal in 1827. Middletown was at the foot of safe navigation in the Susquehanna because of the dangerous falls and rapids at Conewago, but in 1796 a German miller from Huntingdon floated down the Juniata on the first ark ever built in those waters. This was loaded with flour, and safely

ran the rapids to Baltimore. The success of this venture led to the building of many other arks and thus brought about the completion of the canal around these rapids. The delays in opening the Union Canal and in the improvement of the lower river directed the tonnage of Pennsylvania to Maryland. The iron steamboat "Codorus," built at York, made a few trips up and down the Susquehanna between York Haven and Harrisburg about 1825. In 1849 the steamer "Wyoming" ran between Wilkes-Barre and Tunkhannock, carrying passengers and freight.

After the completion of the canals, transportation on the Susquehanna and its branches was confined largely to log and timber rafts, which continued to pass down these streams until within a few years. In 1885 the rafts on the Susquehanna were usually 29 feet wide by 300 feet long, and were composed of logs or squared timbers fastened together in "platforms" of the above width, and varying in length according to the size and character of the timbers, six to eight "platforms" usually constituting a raft. From the woods to Marietta, Pa., the pilot received from $75 to $80; thence to Peach Bottom, 28 miles, $40 to $45 per raft; and finally to Port Deposit, 16 miles, $22.50. At tidewater 20 rafts were lashed together, towed to the Chesapeake and Delaware Canal, and thence by the Delaware River to Philadelphia and New York.

OHIO, ALLEGHENY AND MONONGAHELA RIVERS

The western rivers were not traversed commercially until long after the Delaware and Susquehanna were in constant use, settlements beyond the mountains being delayed by the difficult crossing and by dangers from interference by the natives, so that it was not until after 1795 that the passage could be made with safety. About this time six "adventurous Irishmen started from Philadelphia and, passing up the Susquehanna and Sinnemahoning, penetrated the wilderness of McKean County, built canoes, and launched them at Canoe Place, 2 miles above Port Allegany. Floating down past Olean, they entered the Conewango and made the first settlement in Warren County." It is recorded that the first expedition of the French, to what later became known as Fort Pitt, in 1754, was from Lake Erie by way of Portland at the mouth of Chautauqua Creek, up that valley, across the divide, thence by boats down Lake Chautauqua to its outlet, the Conewango, thence to the Allegheny, and thence down the Allegheny to the Ohio.

Warren on the upper Allegheny became the center of lumbering activity, large rafts continually coming down the streams to be there made up into "floats" for Pittsburgh and Cincinnati. These "floats" were 60 to 70 feet wide and 250 to 300 feet long and frequently carried families to new settlements down the river. One lumber operator frequently sent 20,000,000 feet B. M. to market in a season, and at certain times the shores at Pittsburgh were lined for a mile or two with rafts awaiting a rise in the Ohio to go down to lower markets. Large boats, or "broad horns," so-called from the width of their oars, formed part of the Allegheny craft.

In 1776 two men descended the Ohio from Pittsburgh to New Orleans and brought back gunpowder for the Continental Army. On reaching the falls of the Ohio at the present location of Louisville, Ky., in the spring of 1777, they were obliged to "pack" the cargo around them, but the success of their trip gave an impetus to flatboat traffic on this river and its connecting waterways, the Allegheny and Monongahela.

Keel boats, carrying from 20 to 40 tons, became familiar on the Allegheny, Kiskiminitas and Ohio rivers, and until the canals were built were largely used in the salt industry which flourished for a time in the valley of the Kiskiminitas. These boats were operated both up and down stream by poling. Flat bottomed boats, used only for downstream work and broken up to be sold for lumber at the end of the journey, carried the more valuable farm products and iron from the pioneer charcoal furnaces of western Pennsylvania down the Ohio and the Mississippi to New Orleans. "Bateaux," which were long narrow boats, tapering towards the ends and propelled upstream by poles, oars or sails, were also used on the western rivers. These are said to have cost from $10 to $25 to build.

In 1820 Olean, N. Y., on the Allegheny River, was a prominent point for embarkation of families moving west, and numerous arks laden with cattle, horses, household goods and families floated down the rivers in search of more fertile fields. Many of these unsafe and cumbersome vessels were wrecked on snags and rocks in the Ohio. In 1830 "The Allegheny," a small sternwheel steamboat, made regular trips up the Allegheny River to Warren, and once went to Olean, although the "William Duncan," of 80 tons, which plied between Pittsburgh and Franklin in 1828, was the first steamer on the Allegheny.

In its original condition, flatboats and rafts could be floated down the Monongahela River at high and mean stages, and occasionally steamboats ascended as far as Morgantown and Fairmont, W. Va., but at low stages navigation was obstructed by shoals.

Emigrant traffic down the Youghiogheny from Connellsville was large at one time, as this was the terminus of the overland trail, and arks, flatboats and other craft were built here, proceeding thence to Pittsburgh and the west.

Extensive coal traffic to and beyond Pittsburgh from the mines in the valley of the Monongahela River did not begin until navigation on the river was artificially improved.

"About 20 barges averaging 100 tons each composed the whole of the commercial facilities from New Orleans to the upper country. Each of these performed one trip down and up again to Louisville and Cincinnati within the year. The number of keel boats employed on the upper Ohio is probably not more than 150. These averaged 30 tons each and employed one month from Louisville to Pittsburgh, while the more mobile and dignified barge of the Mississippi made her trip in the space of 100 days if no accident happened ..... Now (1829) the boats make 5 trips within the year and afford to the trade 135,000 tons. Eight or nine days are sufficient for a round trip from Louisville to Pittsburgh, due to the introduction of steam."

After the construction of steamboats and sailing ships began at Pittsburgh, the Ohio bore a heavy traffic to New Orleans and intermediate points and even to foreign lands. During the War of 1812 provisions and supplies from New Orleans to New York and Philadelphia came up the Ohio and overland from Pittsburgh, as coastwise traffic was suspended by reason of the blockade of the several Atlantic ports.

SHIP AND BOAT BUILDING

It was upon the Delaware River that shipbuilding first flourished in Pennsylvania, and it is today the location of a great shipbuilding industry. As early as 1683 William Penn wrote of Philadelphia's industries: "Some vessels have been built here and many boats." In 1718 Jonathan Dickinson wrote: "Here is a great employ for shipwork for England. It increases and will increase and our expectations from the iron works forty miles up the Schuylkill are very great." In these early days the sails and riggings were imported from England. The frigate "United States," built in 1794, was "the fastest ever constructed anywhere." "We surpassed all other people in the skillful construction and fast sailing of our merchant shipping. Our packet ships for quick dispatch of voyage do actually eclipse the world."

Doubtless the first ship built upon the Delaware was the "Amity," a small vessel built by dismantling an old brig. This was built by William Penn in 1683, for the Free Society of Traders. Prior to the Revolution large quantities of lumber were exported in "Raftships," designed and built expressly for the purpose in the extensive shipyards at Philadelphia, and sold in England when timber was in demand. They would carry "eight hundred logs, competent to make six ships of 250 tons each." In 1801 the "Rebecca Sims" of 500 tons was built at the Kensington Yards on the Delaware River, and prior to 1823 had made about 100 Atlantic voyages. In 1807 she made the run from the Delaware Capes to Liverpool in 14 days.

Prior to 1790 no vessel exceeding 300 tons displacement had been built at Philadelphia, but from that date to 1812 shipbuilders on the Delaware took the lead in the size and quality of vessels constructed, this being due largely to the abundance and cheapness of timber available. After the War of 1812 there was a long depression in shipbuilding and most of the orders were for men-of-war and foreign merchantmen. In 1830 the purchase by the East India Company of two ships of 1,800 and 1,540 tons, built at Philadelphia, resulted in drastic action by Great Britain requiring her merchants to use British built vessels. At that time there were 14 shipyards on the Delaware.

Between 1710 and 1894 Philadelphia led all American cities in shipbuilding. During the nine years following the close of the Revolution 162 vessels, having an aggregate tonnage of 18,000, were built there. In 63 years one plant had built 269 ships, and this plant is today engaged in making the largest and most powerful battleships for our navy. The time-honored and battle scarred "Constellation," "Constitution," "President," "Congress" and "United States," the five original frigates of the United States Navy, whose record has never been excelled, were designed by Humphreys of Philadelphia in 1794.

In 1786 Pittsburgh was a small hamlet of 100 log houses, but it rapidly became a center of industry and commerce. As early as 1788, because of the fur trade, which between 1790 and 1800 became extensive, keel and barge boat building was an important industry on the western rivers. About 1800 a company was organized to erect at Pittsburgh a large store, shipyard, rigging and sail loft, anchor smith-shop and everything necessary to build and equip vessels for sea. In 1801 this company built the schooner "Amity" of 120 tons and the ship "Pittsburgh" of 250 tons, both of which were loaded with flour, the former being sent to St. Thomas and the latter to Philadelphia, whence it cleared for Bordeaux. In 1802

the brig "Nanino" of 250 tons, in 1803 the ship "Louisiana" of 300 tons, and in 1804 the ship "Western Trader" of 400 tons, were constructed by the same company.

As the emigrants going west across Pennsylvania sought the nearest navigable rivers, those from Maryland and Virginia coming via Cumberland or Bedford reached the Youghioheny at what is now Connellsville (laid out in 1793), and there started building boats to convey themselves down the rivers toward their destination. A "free space" near the river was dedicated for the use of these emigrants to park their wagons while the arks or flats were building. Thus Connellsville was for a time a busy center of boat building.

A most remarkable and decisive exploit occurred within the embayed harbor of Presque Isle (Erie) in 1813, when it was beyond the pale of civilization, having only a few scattered huts, surrounded by forests, which supplied the materials which in 70 working days were transformed into a fleet, armored, manned and equipped, which should secure to the Nation the right to navigate the Great Lakes free of tolls and to develop the greatest domestic commerce of any waters on the face of the earth. Thus was Perry's fleet created.

STEAMBOATS

Many claimants have arisen for the honor of being the first to apply steam to the propulsion of vessels on water, and its possibilities were being considered almost simultaneously by various inventors. It is certain, however, that an obscure watchmaker of Philadelphia named John Fitch was the first American who made any practical application of the idea. His work began apparently in 1784 and in the following year he petitioned Congress for aid. A successful test was made in 1787 on the Delaware River by a flatboat equipped with a double acting condensing engine and paddles working on the sides, a speed of 3 miles per hour being attained. The following year "The Perseverance," with five paddles on the stern and carrying 30 passengers, attained 7 miles per hour. In 1790 this boat made regular trips up the Delaware to Burlington, 20 miles in 2 hours. In 1804 Oliver Evans built a large scow mounted on wheels with wooden axles, placed an engine on it and ran it by its own power through the streets of Philadelphia to the Schuylkill River, where he equipped it with paddle wheels at the stern and with great facility passed down the Schuylkill and up the Delaware River.

Harris' Directory for 1841, issued after the opening of the canal system, contained a list of 89 steamboats plying within the Pittsburgh district. The first steamboat built in the west was the "New Orleans" in 1811, between which date and 1817 only seven more are named in the lists; but after 1817 they rapidly increased, and in 1825 Pittsburgh steamboats were declared to be the best in the world. Until 1816 the practicability of using steam on the Ohio was doubted, as it was very difficult to pass the "Horse Tail" riffle 5 miles below Pittsburgh. In 1817 a trip was made from New Orleans to Louisville in 25 days as against a usual period of three months by sail or oars. This effected a trade revolution and all kinds of merchandise were brought up the river and packages were delivered at Cincinnati from Philadelphia, via New Orleans, at 1c a pound. The speed was steadily increased until in 1827 the "Tecumseh" entered Louisville from New Orleans in 8 days and 2 hours. In December 1810 the Ohio Steamboat Navigation Company was incorporated to operate under the steamboat patents obtained by Robert Fulton, and built the "New Orleans," 300 tons, 138 feet long on the keel. The first steamboat to operate on the Monongahela River before its improvement was the "Enterprise," a stern-wheeler 80 feet long and 29 feet wide, built in 1814.

Steamboats were soon in general use on the Allegheny and Monongahela rivers both for passenger and freight service. The freight, principally coal, was loaded on barges or flatboats which were made up into large floats or floes, and were directed by a steamboat or steamboats attached to the rear. This mode of transportation is the one in general use on these rivers at the present time.

The building of steamboats at Pittsburgh for the iron trade was once a very prosperous industry, the output of the yards being 141 in the year 1857. The total number built up to that time was over 3,000, but after 1865 the number fell off greatly.

The first iron steamboat built in the United States is said to have been the "Codorus," designed by John Elgar of York, Pa., in November 1825. It was "a boat of sheet iron intended for a passage from Columbia to Northumberland in this state .....It has 60 feet keel ....., weighs 3 tons ....., 9 feet beam and is three feet high. Machinery 2 tons more. The whole cost will be $3,000. She drew, without cargo, only 5 inches and one inch additional for every ton of freight. The engine was 10 horse power and burned hard coal. On the trial trip it carried 100 persons to Harrisburg and later made a number of trips between York Haven and Harrisburg with at least one to Bloomsburg, Wilkes-Barre, and as far north as the New York State line. It was pronounced a great success." Two other steamers were built at York, namely, the "Susquehanna" and the "Pioneer," both of which proved unsuccessful.

CHAPTER III

CANALS AND SLACKWATER

PRELIMINARY STEPS TOWARD CANAL CONSTRUCTION

With a desire to connect the navigable waters of the province more closely, William Penn in 1690 proposed that a settlement be made on the Susquehanna River and that an examination be made as to the practicability of uniting its waters with those of the river Schuylkill, "for a branch of that river lies near a branch that runs into the Susquehanna River and is the common course of the Indians with their skins and furs into our parts." This "way" was by French and Conestoga creeks, and Penn is entitled to the credit of first proposing a waterway between these rivers. Prior to this date, however, in 1613, Capt. Samuel Argall had written that he hoped to see a cut made between the bays of Chesapeake and Delaware, where their tributary waters were but four miles apart; but this proposal later met with such opposition from the early inhabitants of Virginia and Maryland that it came to nothing.

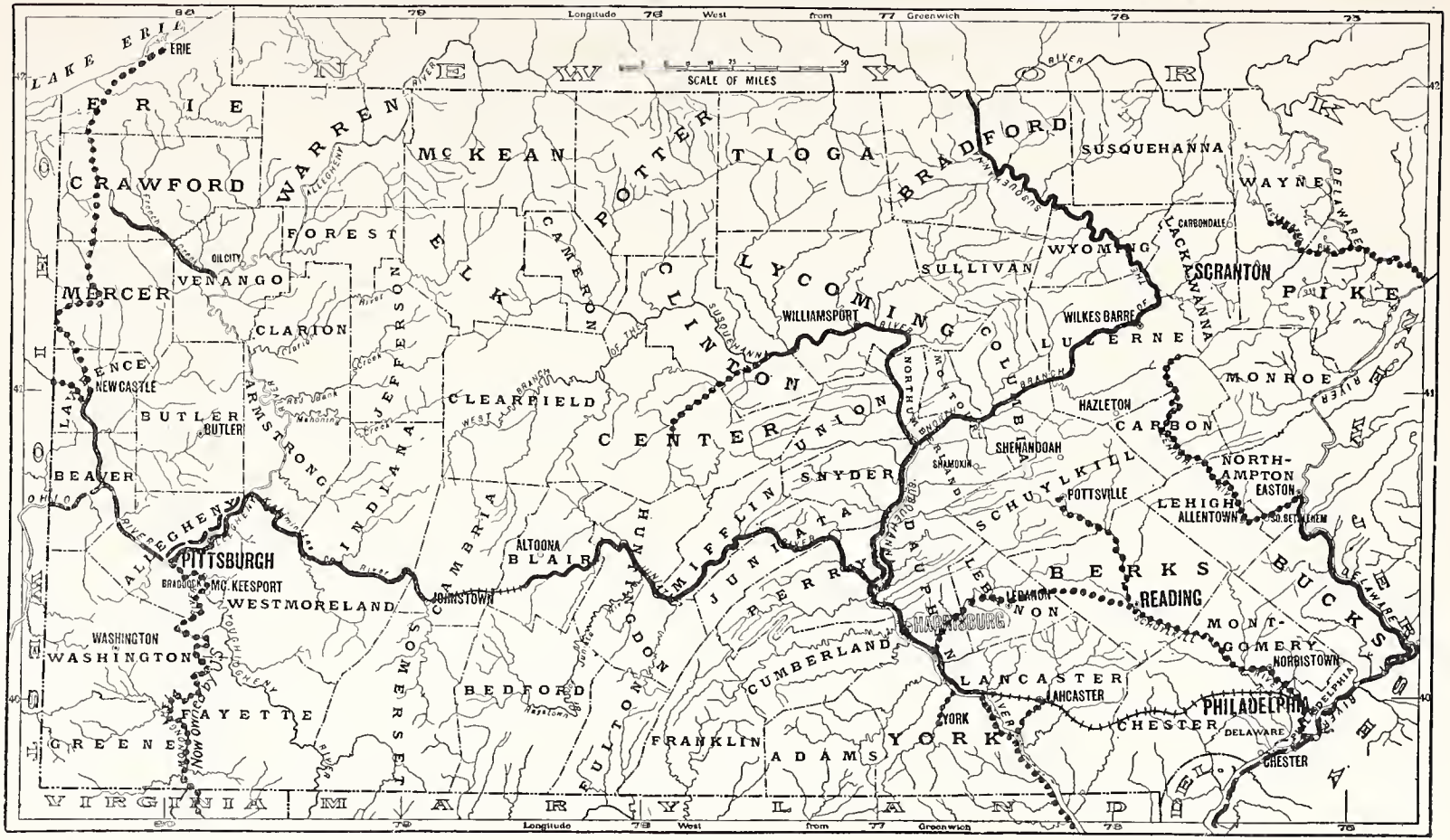
Probably the first step towards the improvement of the rivers of the Commonwealth was the passage of an Act of the Colonial Assembly in March, 1761, authorizing the appointment of a commission of 15 men to improve navigation on the Schuylkill River, which act led eventually to the formation of what is now the Schuylkill Navigation Company. The American Philosophical Society of Philadelphia received from David Rittenhouse and Dr. William Smith suggestions for the improvement of the internal waterways of the Province, to connect the waters of the Susquehanna and Schuylkill rivers by means of Swatara and Tulpehocken creeks. The Society appointed them a Committee, in conjunction with John Lukens, Surveyor General of the Province, and John Sellers, to make a survey of the route, which was done about 1769, and subsequently the Legislature confirmed it by a resurvey and extended it still further to show a plan for joining the headwaters of the Delaware with the Ohio and the western lakes, a project covering 582 miles in all.

In 1772 Benjamin Franklin wrote his observations upon continental waterways at length and recommended engaging a professional engineer at "a handsome salary" to attend to the business as a mat-

CANALS AND SLACKWATER IMPROVEMENTS
CONSTRUCTED BY STATE, UNITED STATES AND CORPORATIONS

Plate I

Built by State: ——— By United States: — — — — By Corporations: ••••••••••



Water Supply Commission of Pennsylvania, Harrisburg, Pa.

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ter of great economy, and advised that to make a navigation practically constant it were better to build canals at a higher level than the flood line of the rivers, which were liable to great injury from washouts and ice, causing frequent interruptions and more expensive repairs, with higher tolls to meet them. He says, "Rivers are ungovernable things, especially in hilly countries. Canals are quiet and very manageable. I warmly wish success to every attempt for improvement of our dear country."

The Revolution exhausted the resources of the Colonies and temporarily suspended all efforts at systematic improvement of the means of communication, but shortly after its close the project was resumed and two companies were incorporated by the Legislature, the first on September 29, 1791, for the union of the Schuylkill and Susquehanna rivers, and the other on April 10, 1792, to join the Delaware and Schuylkill rivers. The Delaware & Schuylkill Canal Company, chartered April 10, 1792, was authorized to build from Norristown to the falls of the Schuylkill and thence to the Delaware, while another company should extend the navigation up the Schuylkill River to Reading, and thence via Tulpehocken, Quittapahilla and Swatara creeks to Middletown, on the Susquehanna, being the route surveyed and recommended by the Committee of the Philosophical Society in 1771. Over 50 years later these works were built along practically these lines. A charter was granted to the Brandywine Creek Navigation Company on April 10, 1793, but it appears that no improvements for navigation were undertaken. Another project actively recommended by the American Philosophical Society was the Chesapeake & Delaware Canal, which, after surveys made in 1765, was finally chartered in 1799 to 1801 by joint action of the legislatures of Delaware, Maryland and Pennsylvania. Active operations were begun in 1803 and continued through 1806, when the company's funds were exhausted and the project remained in abeyance until 1823, when stock subscriptions by the United States, the states of Delaware, Maryland and Pennsylvania, and the City of Philadelphia enabled the company to proceed. Work was resumed in 1824 and the canal was opened in 1829. A large part of its traffic consisted in coal and lumber from the Susquehanna Valley. The Conecocheague Navigation Company was chartered on February 7, 1803, to connect the Susquehanna and Potomac rivers by the Conodoguinet in Cumberland County and the Conecocheague Creek in Franklin County, but this was never built.

The exceptional fertility and rapid settlement of Lancaster County early impelled its citizens to seek an outlet for their products by water, and a charter was secured for the Conestoga Lock and Dam Navigation Company on March 17, 1806, under which slackwater

navigation was projected from Lancaster to the Susquehanna River at Safe Harbor, 18 miles. This project remained inactive until reorganized in 1825 and was completed in 1828.

The Society for Promoting the Improvement of Roads and Inland Navigation, which was founded with over 100 members, petitioned the Legislature in 1791 for aid to reduce the cost of overland hauling between Middletown and Philadelphia, which was then $14.66 per ton, by opening the waterways of the state, and in that same year £20,270 were appropriated for the "clearing" and making navigable certain portions of the Delaware, Lackawaxen, Lehigh, Schuylkill, Susquehanna, Juniata, Sinnemahoning, Allegheny, Conemaugh and Kiskiminitas rivers and French Creek. In 1792 the rivers were given £3,000 more by the State.

In January 1791 a committee was appointed to examine the reports of commissioners employed in exploring the western waters of the Susquehanna, the Delaware, etc., for the purpose of improving navigation thereon, and on February 19, 1791, they reported that the Delaware River was an important stream for introducing trade and for produce, and that by a portage of 19 miles connection could be made with western New York, and by two other short portages with Lake Ontario. They further reported that at small expense the Lehigh, "Lackawach" and Schuylkill rivers could be improved for boat and raft navigation. At this time anthracite was found near Mauch Chunk and a company formed to develop a large tract of coal land, but the difficulties of transporting it to market were insuperable and the enterprise was abandoned. From these beginnings the system of state canals and improved waterways was 35 years later developed, $40,000,000 being eventually expended thereon by the Commonwealth.

It would thus appear that for the half century preceding the War of 1812 the only available improvement made by the State was that around the rapids on the Susquehanna at Conewago, 2¼ miles long, opened in 1797. Below this canal there was a boat channel on the east side extending to the state line. A small amount of work had been done on the Schuylkill and Susquehanna (Union) Canal covering some 15 miles of rock work, with heavy embankments and several brick locks partially completed, at a total cost of $440,000, when work was suspended for lack of capital. Some expenditures had also been made in removing obstructions and improving channels in the Delaware, Lehigh, Schuylkill and Lackawaxen.

Following these surveys and abortive attempts to provide better transportation facilities, two systems of waterways eventually were constructed—one by the State and the other by private interests—while later the Federal Government undertook the improvement of some Pennsylvania streams. The work was delayed by the Revolution

and the War of 1812, both of which so crippled finances that great works of this kind could not be built until time had elapsed in which to recuperate. The state and private canals were built largely during the period between 1825 and 1850, and their interests were, as a rule, in harmony. Those constructed by the State are treated first in this report, those built by private companies following.

STATE CANALS

The approaching completion of the Erie Canal through the low grade route in New York State from Buffalo to Albany (opened in 1825) doubtless inspired some of the enterprising citizens of Pennsylvania," which met in Philadelphia November 26th and organized on Promotion of Internal Improvements in the Commonwealth of Pennsylvania," which met in Philadelphia November 26th and organized on December 14th, 1824. It immediately petitioned the Legislature to create a Board of Public Works and issued pamphlets advocating the building of roads, canals and bridges by the State. On February 3, 1825, this Society, having subscribed the necessary funds to defray expenses, sent William Shackland and Samuel Kneass to Europe to investigate and report upon public works in foreign countries. These gentlemen, upon their return, submitted an elaborately illustrated report as a basis for the development of the lines of communication of this state.

On April 6th the Society resolved, "That the improvement of the Commonwealth will be best promoted and the foundations of her prosperity and happiness most securely established by opening an entire and complete communication from the Susquehanna to the Allegheny and Ohio and from the Allegheny to Lake Erie by the nearest and best practicable route; and that such a work is indispensably necessary to maintain the character and standing of the state and to preserve her strength and resources." In its first annual report, dated at Philadelphia January 4, 1826, signed by Mathew Carey, Richard Peters, Jr., William Lehman, Joseph Hemphill and Stephen Duncan, it was stated that "The navigation of every one of the great rivers of the state for steamboats is now fully and decidedly ascertained to be within the power of the State.

"By the construction and employment of *'the Codorus'* upon the Susquehanna (in 1825) the most important fact has been established and they, our rivers, will be restored to that rank.....

to which they have always been entitled, but of which a neglect of their capacity for improvement and to be constantly employed had almost deprived them."

In 1824 Governor John Andrew Schulze appointed, under a law passed March 27, 1824, three Canal Commissioners to explore the following proposed canal routes:

1. From Harrisburg to Pittsburgh, by the Juniata and Conemaugh rivers, also by the West Branch of the Susquehanna and Allegheny rivers, and between the Schuylkill and Susquehanna rivers through Chester and Lancaster counties.

2. From the Schuylkill River in Schuylkill County, by Mahanoy Creek, Susquehanna River, Moshannon or Clearfield and Black Lick creeks, and then by way of the Conemaugh, Kiskiminitas and Allegheny rivers to Pittsburgh. They reported favorably on February 2, 1825. Thus was an active start given to the great state canal system, which was later to weave a network of artificial waterways over the state. The Canal Convention of August 1825 gave an impetus to the cause of public improvement and resulted in innumerable petitions being circulated throughout the Commonwealth to be signed and presented to the Legislature, praying for canal construction along nearly all of the rivers and larger creeks in the state.

The Construction of the State Canals

On February 25, 1826, an act was passed authorizing the construction of 54 miles of canal from Middletown, Dauphin County, the end of the Union Canal, to the mouth of the Juniata River, and from the mouth of the Kiskiminitas to Pittsburgh, as well as further explorations and surveys. The best route over the mountains had not then been selected but the two sections thus authorized would be common to all routes proposed. The Canal Board was subsequently, April 10, 1826, increased to nine, and the following year authority was given for the location and construction of a canal from the mouth of the Juniata River up that stream to or near Lewistown, and a canal from the mouth of the Kiskiminitas River up that stream and the Conemaugh to Blairsville, together with a canal up the Susquehanna River from the end of the section already authorized at the mouth of the Juniata to Northumberland. On July 4, 1826, ground was broken for the first section between Middletown and the mouth of the Juniata River along the east bank of the Susquehanna River. Surveys were also authorized to determine on a portage road over the Alleghenies to connect the two ends of the canal already authorized; for an extension up the North Branch of the Susquehanna River from Northumberland to the state line; from the mouth of the Kiskiminitas

River, by way of the Allegheny River and French Creek, to Lake Erie; and from Pittsburgh, by the Ohio, Beaver and Shenango rivers, to Lake Erie. Surveys were made for railroad and canal between Philadelphia and Columbia, on the Susquehanna River, for a connection between the North Branch of the Susquehanna and Lehigh rivers, and for canals down both sides of the Susquehanna River from Middletown to the Maryland-Pennsylvania State Line. For the prosecution of this work $1,000,000 was appropriated.

In March 1829 further surveys and the construction of sections of the canal and the railroads were authorized. A railroad across the Allegheny Mountains to connect the two ends of the canal, and one from Philadelphia, via Lancaster and Columbia to York, were authorized by this act. Surveys were ordered along the Monongahela River from Pittsburgh to the Virginia State Line; from Columbia to Conestoga Creek, in Lancaster County; and along the Ohio River from Pittsburgh to the mouth of the Beaver River. To carry out these further improvements $2,000,000 was authorized to be borrowed.

From this time forward the construction work was pushed rapidly: the railroad from Philadelphia to Columbia (81.6 miles), the canal from this point to Hollidaysburg, Blair County, by way of the Susquehanna and Juniata rivers (181.5 miles), the portage railroad over the Allegheny Mountains to Johnstown (36.69 miles), and the canal from Johnstown to Pittsburgh, via the Conemaugh, Kiskiminitas and Allegheny rivers (104 miles with "feeders"), a total of 403.79 miles were finished and opened in 1834. The Susquehanna line was built from the mouth of the Juniata River up the west bank of the river crossing the West Branch to Northumberland (41 miles in all), and thence up the west bank of the North Branch through Danville and Wilkes-Barre to Lackawanna Dam (72½ miles), and another section up the east side of the West Branch through Williamsport and Lock Haven to Farrandsville (76 miles).

The purpose of the Legislature in selecting the two routes to the west was to complete both to the Great Lakes, the former by way of the Ohio, Beaver and Shenango rivers, and the latter by way of the West Branch of the Clarion and Allegheny rivers and French Creek. Pennsylvania recognized that Philadelphia, its seaport, was entitled to some of the trade which passed from the northwest through the Lakes and the Erie Canal to New York.

Along the Delaware River also a canal was built from tidewater at Bristol, 18 miles above Philadelphia, to Easton, at the mouth of the Lehigh River, 60 miles in all. This line was intended to deflect the anthracite trade of the Lehigh Valley to Philadelphia, instead of permitting it to go to New York by way of the Delaware & Hudson and the Morris canals.

In the west, canal and slackwater navigation was completed along the Beaver River from its mouth 30.75 miles up that river, the Shenango River and Crooked Creek, at a cost of $519,365. Of this section 8 miles was canal and 22 miles slackwater, effected by seven dams. The importance of this line lay in its contemplated connection of the Great Lakes with the Ohio River, and thence through the Pennsylvania Canal to Philadelphia to draw traffic away from the Erie Canal. The extension of this line over the divide to Erie was undertaken and $3,196,149 was spent on construction, but before its completion the whole line, including the Beaver Division, was sold to the Erie Canal Company in 1845. The Beaver Division was operated from 1834 to 1845, the total revenue received from it having been $38,312, while the operating expenses were $210,360.

Projected Lines

About 1841 an extension of the West Branch Division to the mouth of Sinnemahoning Creek, which had been begun in 1838, was likewise abandoned after $353,000 had been expended. This line was estimated to cost $1,285,868, was 33 miles long, and had 17 lift locks. It was planned to eventually extend the West Branch Division beyond the end of the Sinnemahoning extension, crossing the summit to the Allegheny Valley, and from there extend one line southward to meet the Kittanning feeder, and so to connect with Pittsburgh; and another line to continue, probably by way of French Creek (Franklin line and French Creek feeder) and the Erie extension through Conneaut Lake to Lake Erie at the city of Erie.

A survey was made in 1837 for a branch canal to follow Penns Creek from the Susquehanna Division at Selins Grove, Snyder County, to New Berlin, Union County, but this line was never built. It involved, approximately, 11 miles of canal and lockage of 63 feet by means of nine locks, and the estimated cost was $184,560.

A navigable feeder was begun to follow the west side of the Allegheny River from a point opposite Kittanning, where a dam was to be built, down about 14 miles to connect with the Pennsylvania Canal, at the mouth of the Kiskiminitas River. This was put under contract in 1838 but never completed, being abandoned after $31,591 had been spent and no revenue received.

A survey was also made in 1838 to determine the feasibility of canal or slackwater navigation along the Raystown or southern branch of the Juniata River. This plan was reported favorably and involved about 54 miles, on which 23 dams would have to be constructed, but the work was never undertaken.

A line was also begun to follow up the east bank of the Susquehanna from the mouth of the Juniata River to the mouth of Wiconisco Creek at Millersburg, where it would reach the Lykens Valley coal operations. The line was to be 12½ miles long, but in 1850, before completion, after having cost $393,440, it was sold, never having brought in any revenue to the state.

Delaware Division

The Delaware Division Canal from Easton, at the mouth of the Lehigh, to Bristol, which proved to be the most profitable division owned by the State, was built chiefly to supplement the Lehigh Canal and to offer an outlet into Philadelphia for coal coming down that line, instead of permitting it all to go by way of the Morris Canal to New York. The Legislature had previously refused to permit the Lehigh Coal & Navigation Company to improve the Delaware River, having in mind at the time the construction of this line. In 1827 the Legislature made its first appropriation for this line, and it was then estimated that it would cost about $686,600. It was finally completed and put in use in 1832, at a total cost of $1,238,027.69. The canal was 60 miles long, involving 28 locks, overcoming 164 feet of elevation. The width at top was 25 feet, locks 11x90, and depth 5.0 feet, carrying 67-ton boats. Difficulty was found in maintaining water in the canal, New Jersey objecting to Pennsylvania taking water from the Delaware River. Owing to poor construction it had to be rebuilt, and additional water, which at first had come entirely from the Lehigh, was obtained from the Delaware River and Durham and Milton creeks, that from the former being pumped by water power at Wills Falls. The canal immediately proved to be too small for a true supplement to the Lehigh line, which was larger, deeper and better supplied with water, and from 1850 to 1854 enlargements were made which added materially to its value and brought the construction cost up to $1,500,000. Coal from the Lehigh Canal was the principal traffic, the tonnage in 1855 being 755,265 tons. The toll on coal was 6 mills per ton per mile. The net income of this division from 1852 to 1855, when it was at its most prosperous period of state ownership, varied from 14 to 22 per cent. The line was sold to the Sunbury & Erie Railroad Company in 1858, almost at the height of its prosperity, while a second improvement to 6 feet depth and larger locks was in progress, and subsequently passed under control of the Lehigh Coal & Navigation Company.

"In December 1835 the country was congratulated by the then Executive and Commissioners, on the signal success which had attended our system of internal improvements," "after nine years of unremitting toil and untiring perseverance in the construction of

upwards of *six hundred miles* of canal, and *one hundred and twenty miles* of railroad." The timid were told to rest satisfied, that the revenue derivable from the canals and railroads of the Commonwealth would within a few years pay the interest and ultimately discharge the principal borrowed for construction. Further extensions were recommended: "(a) the North Branch extension to the New York State line; (b) the extension to Erie, on account of their intrinsic value as a part of the original design; and in addition a canal from Conneaut Lake to the Beaver Division; a canal and slackwater from the head of the West Branch Division to the Allegheny River; a canal from the Kiskiminitas Aqueduct, or steamboat navigation to Franklin; a slackwater navigation on the Monongahela; a canal from Pittsburgh to connect with the Beaver Division and thence with the Big Sandy Canal."

Tables Nos. 1 and 2 show respectively the lines built and operated by the State and those begun but not completed.

TABLE No. 1. *Canals Completed and Operated by State*

Division.	Year.	Total length in miles.	Length of canal.	Length of slackwater.	Number of dams.	Number of locks.	Lift in feet.	Depth in feet.	Width of top.	Disposition by State.	Present Condition.
Delaware, Easton to Bristol, ...	1832	60	60	0	2	28	164	Original 5 ft., enlarged to 6 ft.	25	Sold to Sunbury & Erie R. R., and then to Delaware Canal Co.	Operating under 99 years lease by Lehigh Coal & Navigation Co.
Eastern, Columbia to Hollidaysburg, .	1830	179	163	16	21	111	670.5	Original 4 ft., enlarged to 5 ft.	40	Sold to P. R. R. and by it to Canal Co.	Abandoned—part in 1889 and part in 1901.
Raystown & Johnstown Feeder, ...	.....	2.5	.....	.....	.....	.....	.....	.....	.....	Sold to P. R. R. and by it to Canal Co.	Abandoned—part in 1889 and part in 1901.
Western, Johnstown to Pittsburgh, ..	1831	104	82.75	21.25	11	65	470	5	40	Sold to P. R. R. and by it to Canal Co.	Abandoned in 1870.
Allegheny City Branch.	.....	0.75	.....	.....	.....	.....	.....	.....	.....		
Susquehanna, Duncan Island to Northumberland.	1832	42	42	0	1	16	86.5	5	40	Sold to Sunbury & Erie R. R. and by it to Canal Co.	Abandoned in 1901.
West Branch, Northumberland to Farrandsville.	1834	76	76	0	5	24	138.5	5	40	Sold to Sunbury & Erie R. R. and by it to West Branch Canal Co.	Abandoned in 1889-1897.
Bald Eagle Side Cut, ...	.....	3.6	.....	.....	.....	.....	.....	.....	.....	Sold to Sunbury & Erie R. R. and by it to West Branch Canal Co.	Abandoned in 1889-1897.
Lewisburg Side Cut, ...	.....	0.6	.....	.....	.....	.....	.....	.....	.....	Sold to Sunbury & Erie R. R. and by it to West Branch Canal Co.	Abandoned in 1889-1897.
North Branch, Northumberland to mouth of Lackawanna River.	1833	73	73	0	2	14	.....	5	40	Sold to North Branch Canal Co.	Abandoned in 1901.
Lackawanna Feeder, ...	.....	0.25	.....	.....	.....	.....	.....	.....	.....		
Beaver, Rochester to 6 miles above New Castle.	1834	30.75	8.75	22	7	17	132	5	40	Sold to Erie Canal Co....	Abandoned in 1870.
French Creek Branch, from Franklin up French Creek.	1834	22.25	.....	.....	.....	.....	.....	.....	.....	Lower portion abandoned 1845.	
Total, ...	.....	*594.70	.....	.....	.....	.....	.....				—

*This does not include the Columbia and Portage railroads, which were part of the state works and aggregated 118.29 miles.

TABLE No. 2. *Canals Begun By State But Not Completed*

Name.	Length in Miles.	Disposition.	Remarks.
Wiconisco Line, Duncan Island to Millersburg, ...	12.25	Sold to Wiconisco Canal Co..	Abandoned in 1889.
North Branch Extension, Lackawanna River to Athens,.....	94.5	Sold to Sunbury & Erie R. R. Co., ...	A large part of this line was completed and opened for use—rest abandoned.
Sinnemahoning Extension, up West Branch Susquehanna River to Sinnemahoning.	33	Sold to Sunbury & Erie R. R. Co., ...	Abandoned before completion.
French Creek Feeder, ...	27	Sold to Erie Canal Co., ...	Abandoned before completion.
Kittanning Feeder, up Allegheny River towards Kittanning,	14	.....	Abandoned before completion.
Erie Extension, New Castle and Erie, ...	105.5	Sold to Erie R. R. Co., ...	Completed after sale by State by Erie Canal Co.
Total, ...	286.25		

Operation of State Canals

The report of the State Treasurer and Auditor General made in 1854, in response to a resolution of the General Assembly, shows that the total first cost of the state improvements, including the Philadelphia-Columbia Railroad and the Portage Railroad, was $32,542,268, the cost of the canals alone being $24,556,318. The cost of the canals which were completed and put in operation was $15,606,890 and the cost of those begun but never operated was $8,949,428.

The net revenue from the operating canals up to 1854 was $3,176,557, which would be equivalent to 1.1 per cent per year for 20 years on their first cost; while in the year 1856, the last year before the sale of the main line, the total net earnings of the operating canals were $601,174, equivalent to 4.2 per cent on their first cost.

Up to and including 1863 the total cost of operating the finished canals, including collectors, weighmasters and lockkeepers, was approximately $1,100,000, while for the same period the cost of maintenance, improvements and repairs was $7,600,000, thus showing the heavy expense required to keep the lines in condition to operate.

The financial status of the state works up to January 1, *1852,* as reported to the Thirty-second Congress, in Executive Document No. 112, page 112, is as follows:

Division.	Length.	Cost.	Revenue.	Expenditures.	Net returns.	Per cent.
Main Line,	396	$15,056,077	$17,026,100	$11,987,132	$5,038,968	33
Delaware,	60	1,384,606	2,238,694	1,117,716	1,120,978	81
Susquehanna,	39	897,160	402,779	554,835	—152,056	loss.
North Branch,	73	1,598,379	1,003,047	753,662	249,385	16
West Branch,	72	1,832,083	449,058	738,470	—289,412	loss.
Totals,	640	$20,768,305	$21,119,678	$15,151,815	$5,967,863	29

From which it appears that under state control, during the 18 years after completion, these 640 miles had earned nearly $6,000,000 net on an investment of $20,768,305. The Delaware Division was much more profitable than the others, two of which indicate losses.

At that date there were 314 miles of the proposed state works yet to be completed at an estimated cost of $7,712,531. as well as other contingent expenditures for surveys and salaries of officials, making a total cost of $30,057,077 for 1,024 miles. (Report J. D. Andrews—Trade and Commerce North American Colonies.)

In a historical brief on the North Branch work, by John H. Dager, as published in the Reports of the Chief of Engineers for 1884, page 874, it is said: "The North Branch Canal, 73 miles of which are completed, cost $2,484,939.60, and the estimate for the extension thereof $1,580,670.87."

W. Hasell Wilson gives the amount expended by the Commonwealth upon the "North Branch *extension*" as being $4,643,491 up to 1858 and its length from Lackawanna to the state line as 94¼ miles.

The amount of loans effected by the State for internal improvements from the commencement thereof in 1826 to April 1, 1844, was $46,736,601.18, and the premiums on the same amounted to $1,358,778.36, making a total of $48,095,379.54.

In 1830 the Board of Canal Commissioners was reduced to three, the original number, and remained of that size until its dissolution in 1859. To this Board was delegated complete control of the surveys, construction and operation of the canal and railroad lines of the state. The selection of routes was kept in the hands of the Legislature, as was also the appropriations for construction, improvements, repairs and operation. After the lines were finished, the Board set the rates of toll, and when once set they could not be altered until the first of the following year. All moneys received as tolls or otherwise were paid into the State Treasury and the Board could not spend any funds unless specifically authorized and appropriated for a specific purpose, thus causing difficulties in the repairs of extraordinary damage. The Board was in constant service, traveling over the state lines and holding meetings and making inspections at all points.

Tolls

The State did not operate boats on its lines, never entering the transportation business, but simply built and maintained the lines as public highways, just as the toll road companies do today. Numerous transportation companies were organized with the completion of the canals, and these companies built and operated boats, some of them maintaining as nearly as possible a regular schedule of through and local traffic. These companies or individuals operating their own boats paid toll to the State on the boats and their burden. The first tolls were fixed by the Board in 1829, and were entirely separate and distinct from the freight charges, which were set by the various transportation companies doing business over the lines, and must be added thereto to obtain the total cost of transportation. The following were the tolls on the principal articles shipped, as set for 1831:

TABLE No. 3. *Tolls on State Canals in 1831*

Material.	Price Per Ton Per Mile.
Agricultural tools, wagons, etc., Horses, cattle,	1.5 cents.
Lumber in planks and boards,	1.0 cent per 1,000 B. M.
Butter, lard, cheese,	1.5 cents.
Coal,	0.5 cent.
Corn,	1.5 cents.
Flour,	1.5 cents.
Hardware,	2.5 cents.
Iron ore,	1.0 cent.
Lime,	1.0 cent.
Salt,	1.5 cents.
Boats,	3.0 cents per mile.
Passengers,	0.75 cent per mile.

Later the tolls were much reduced, and the various commodities transported were classified and a toll established for each class, varying from 1 to 6 mills per ton per mile. The following rates for various commodities are given in the 1834 Report of the Canal Commissioners:

TABLE No. 4. *Tolls on State Canals in 1834*

Nature of Freight.	Points.	Time.	Cost.
Merchandise, ...	Philadelphia to Pittsburgh,..	8 days, ...	$1.00 per 100 lbs.. .054 per ton per mile.
Merchandise, ...	Philadelphia to Cincinnati...	12 days, ...	$1.30 per 100 lbs.
Cotton, ...	Tennessee to Philadelphia,..	.....	$1.125 per 100 lbs.
Flour, ...	Pittsburgh to Philadelphia,..	.....	$1.125 per 100 lbs.

These great public works were practically complete in 1834 although additions, extensions, enlargements, feeders, etc., were being continually made. They involved an expenditure of about $40,000,000 and their construction covered the period from July 4, 1826, until March 1834, when the main lines were reported as complete. The total length of the completed state lines, including canals and slackwater, was approximately 600 miles (see Table No. 1), while the unfinished lines, abandoned or sold, amounted to about 290 miles.

The canals were usually closed from December to March and with the opening each year, repairs, renewals and improvements were found to be necessary, thus using up large portions of the toll receipts.

Water Supply

The water supplies for the various divisions were derived chiefly from the large rivers whose valleys they traversed, by means of diversion dams and feeders, some of the former being still in existence on

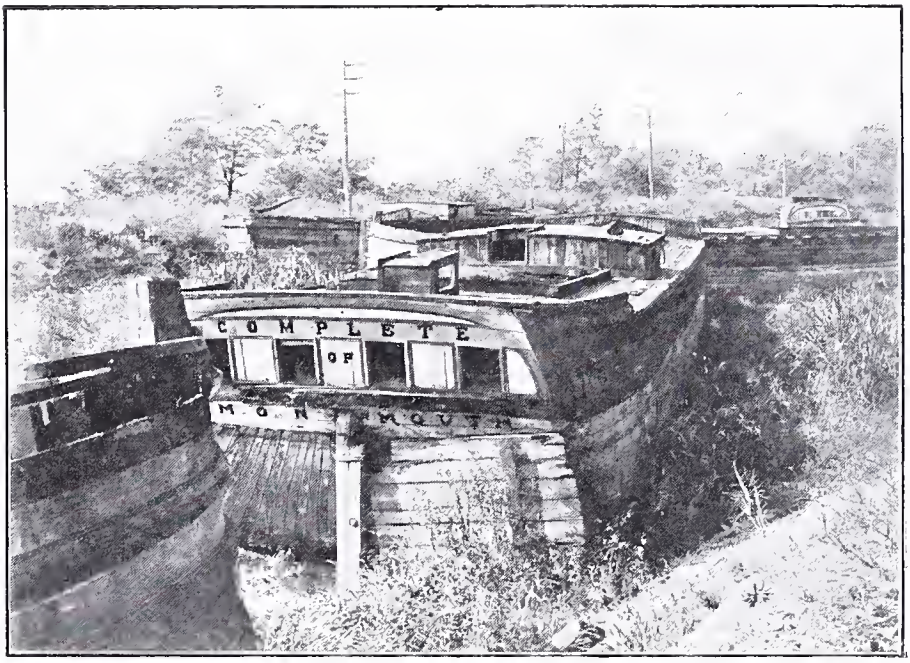
the Susquehanna and Beaver rivers, French Creek, etc. Droughts frequently caused lack of water for operation with the consequent more or less extended shutdowns and loss of revenue, while floods caused extensive damage and necessitated costly repairs and shutdowns.

The operation of the upper levels at Johnstown on the west and Hollidaysburg on the east gave much trouble from lack of water during dry seasons, and storage reservoirs were built on both slopes of the mountains from which additional supplies were drawn as occasion demanded. The west side was supplied from the western reservoir, built on the South Fork of the Conemaugh River 10 miles above Johnstown, having an available capacity of 480,000,000 cubic feet, the breaking of which caused the great damage by flood at Johnstown in 1889. The east side was supplied by the eastern reservoir, on the South Branch of the Juniata River, 1½ miles from Hollidaysburg.

An extraordinary rain on June 19, 1838, continuing for about two hours, around Hollidaysburg, caused a disastrous flood in the Juniata River and swept away almost the whole of the public works from Hollidaysburg to Huntingdon, including canal banks, dams, locks and viaducts, and it was not until November 21, 1838, that repairs were finished and the canal reopened. Occurring on the main line, this flood blocked traffic throughout the system and seriously reduced the tolls. Built as these canals were, without previous study of the extent of floods or the duration of droughts, it is little wonder that these misfortunes befell them, and it was chiefly these physical obstacles which led to the final abandonment or disposition of the state canals to private interests. Had public opinion and clamor not forced the undertaking of these great public works so precipitately, and had those in whose charge the work was to be done been permitted time for proper investigation and preliminary study, the history of Pennsylvania canals might have been quite different.

The state canals were nearly all designed along similar lines and the endeavor was evidently to maintain them so that transportation might be continuous from one to another. The usual depth, as designed, was 4.5 feet to 5.0 feet, width at top 40 feet, with locks 15 feet wide and 90 feet long. They were generally planned with more foresight than some of the corporate works and were not so constantly being enlarged, although some of the lines were deepened to 6 feet and the locks enlarged. In fact it was in some cases the larger size of the state canals that necessitated the enlargement of some private lines in order to handle traffic brought to them. The notable exception to this was the Delaware Division Canal, which was planned too small to handle the traffic from the Lehigh Canal upon which it was largely dependent for business.

Plate II



Relics of the State Canal at Columbia, on the Susquehanna River

Of all the lines constructed by the State the only section now (1914) in operation is the Delaware Division, along the Delaware River from Bristol, Bucks County, northward to Easton, 60 miles in length, which is operated by the Lehigh Coal & Navigation Company. These highways served the purpose for which they were intended—to open lines of traffic and afford cheap communication between all parts of the state and aided in the settlement and development of the Commonwealth. As we look back over their history, note the feverish enthusiasm with which they were undertaken, and then read the record of their decay and abandonment, it seems that these canals were no sooner completed than they were abandoned or sold; and at this distance of time the long interval of nearly 30 years during which they were in active operation carrying state and interstate trade is easily passed over. During much of this time they were the great and crowning achievement of the state.

Sale of State Canals

The state canals were eventually snperseded by a transportation agency which, by tapping the source, withdrew the traffic and either leased or destroyed its competitors. To have so improved the canals at the time of their sale as to compete with the railroads would have meant enlargement and complete standardization between state and corporate lines, as well as the construction of many feeders and local extensions. All this would have involved heavy expense to the Government, at a time when the people of Pennsylvania had expressed themselves as decidedly opposed to further expenditures for this purpose.

As has already been stated, the greatest activity in state canal construction was between the years 1827 and 1835. Subsequently the work continued on a smaller scale for some years, but owing to the financial panic of 1837 and the succeeding money stringency, the credit of the State was greatly impaired, and it was found advisable to suspend work on costly public improvements. It was soon realized also that much of the original work had been of a temporary character which rapidly deteriorated. Moreover, so much difficulty came with the adjustment of rates and damage claims that finally charges were preferred against the Board of Commissioners and legislative investigations were instituted. Failure of tolls to meet expectations and constantly increasing cost of maintenance raised the state debt to a total of $40,000,000, despite the fact that the Legislature enacted a tax on tonnage carried by railroads, which tax assisted the canal in competing for traffic, and public opinion demanded the disposal of the system to private companies. Finally on the 29th of April, 1844, an Act of Assembly was passed providing for a popular vote on the

question, and at an election in the succeeding autumn a majority of the votes cast were in favor of the sale. Commissioners were appointed in 1845, but the sale was not consummated and for about ten years the system continued under state administration. On April 27, 1854, another Act of Assembly was passed inviting proposals for the Main Line of the Public Works from Philadelphia to Pittsburgh. A proposal to purchase this line was made to the Pennsylvania Railroad Company, but was declined on March 22d, because "the canal was inadequate for public service required and its future may be traced to the fact that a second class canal broken by three transhipments to and from railroads cannot compete upon equal terms, with a continuous canal, such as that of New York, or of the continuous railroads of New York, Maryland or even Pennsylvania, the tonnage of which is untaxed though leading to outside markets." An act approved May 8, 1855, directed advertisement of a public sale within ninety days, but no sale was effected until additional legislation, approved May 16, 1857, formed the basis of an agreement resulting in the sale of the Main Line to the Pennsylvania Railroad Company on June 25, 1857.

The reasons above given are still pertinent as indicating the requirements of successful routes by water and the necessity of continuous and direct movements, and these are physically possible over a large portion of the territory enclosed within state boundaries. In fact the public press has only this year (1914) reported a project for a continuous water route passing the Alleghenies by a long tunnel and estimated to cost more than the Panama Canal, but this same suggestion was anticipated as early as February 3, 1826, when the Commissioners appointed under the Act of April 11, 1825, were of the opinion that the project to secure "a navigable communication between the Allegheny and Susquehanna rivers, across the great ridge which divides the eastern and western waters of the state" was impracticable and "The Board was not favorably impressed with the tunnel plan" and appeared to consider as better the Juniata route with a railroad portage over the Alleghenies, which was subsequently adopted.

On June 25, 1857, by authority of the Act of May 16, 1857, the Main Line, including the Columbia-Philadelphia and the Portage railroads, was sold to the Pennsylvania Railroad Company, chartered in 1846, for $7,500,000, possession being given August 1, 1857. On May 19, 1858, the North Branch, the West Branch and the Susquehanna divisions, and the Delaware Division Canal, were sold to the Sunbury & Erie Railroad for $3,781,250. The total price received by the State for these lines was, therefore, $11,261,250. The Canal Commissioners used all means to prevent the sale, urging that the act was unconsti-

tutional and that the repeal of the tonnage tax would be detrimental to the State's interests. The Supreme Court of Pennsylvania, however, upheld the constitutionality of the Acts of Assembly. With the sale of the last of the state canals the Board of Canal Commissioners was abolished, its last meeting being held on January 25, 1859.

The main line, including railroads, had cost originally $16,472,634, and had been much improved and strengthened by the time of the sale, about $15,000,000 having been spent on maintenance and repairs during the State's ownership. During the year 1856 the earnings exceeded the operating, maintenance and repair expenses by $382,596, being equivalent to 2.35 per cent on the first cost, or 5.2 per cent on the price received. The lines sold to the Sunbury & Erie Railroad Company had cost $5,897,224 to build, and the average of seven years preceding the sale indicates that the revenue for that period equaled 7.55 per cent on the first cost and 11.7 per cent on the price received for them.

Defects of the System of State Works

To connect the basin of the Ohio with the Delaware River as desired, it was necessary to cross the Appalachian and Kittatinny divides. As the former rises to an elevation of about 2,600 feet above sea level and has insufficient water to supply a summit level at that altitude, all water borne traffic was carried in sectional boats hauled over the mountain on inclined planes, operated by stationary engines driven by steam, thus increasing the cost over that by the continuous Erie Canal through the Empire State. Moreover, the dimensions of the Schuylkill-Susquehanna (Union) Canal were too small to pass the boats built for the traffic of the Susquehanna basin, and after the completion of the Tidewater Canal to the head of Chesapeake Bay the rates on the latter were held so high by the competing interests as to greatly restrict the tonnage. The elevation of the works also was such as to permit high floods to submerge and destroy them, involving heavy expenses for maintenance, and while the railroads, their chief competitor, by laying tracks directly to the mouth of the mines, intercepted the tonnage of the mines at its source and saved one or more transhipments.

This policy of railroad aggression ultimately crippled the revenues of the canals and led to their acquirement by competitors, which sold or abandoned them and utilized the towpaths as grades for railroad tracks. The destruction of these most valuable public utilities is well set forth by the Legislative Committee of New Jersey, appointed in 1909 to report upon the causes for the decadence of the Delaware and Raritan Canal. This Committee reported that this canal, which had a maximum tonnage in 1866 of 2,857,233 tons and carried a large

part of the coal shipments from the Reading system through to Perth Amboy, was leased on June 30, 1871, to the Pennsylvania Railroad, and soon thereafter the tonnage decreased steadily to 401,231 in 1909, and the revenues did not suffice to cover even the cost of operation. "It is very significant that the decline of the canal has been steady since the rates were raised to their maximum height in 1882 and that these rates still obtain in spite of such decline." It is also significant that a few months after its lease, or on January 2, 1872, the Reading Railroad leased for a period of 999 years, at $20,000 per annum, the Susquehanna (Tidewater) Canal, at the outlet of the system of the state works, which had been purchased by the Pennsylvania Railroad in 1857, and thus controlled the distribution by raising the tolls to such an extent as to throttle the traffic and compel the competing road to carry the coal overland by rail at greater cost, increasing its market price and checking industrial developments. In 1894 this canal was washed out by heavy floods and never repaired because of the diversion of its tonnage, and in 1905 the property was sold to the McCall Ferry Power Company, which has since erected a concrete dam across the river a few miles above the Pennsylvania-Maryland State Line.

Physical Relief

There is no doubt that transportation in bulk by water, whether in natural or artificial channels, can usually be conducted more cheaply than by rail or wagon roads, and that it is of great value to the railroads, as well as to the public, in supplying raw materials and low grade freight. The policy of exterminating the water routes is detrimental to the best interests of the Commonwealth, and the leasing of these waterways to competitors, with authority to charge prohibitive rates, to discriminate in favor of railroads and to fail to provide or to encourage the building of boats and suitable terminals, is "in restraint of trade" and has caused the almost complete extermination of the entire system in this and other states within the last half century. Notwithstanding the great increase in the number and capacity of the cars since commerce increases fivefold faster than population, the necessity of handling so many units at the terminals, even under systematic management, causes congestion in the yards and reduces the efficiency of this method for which no adequate relief can be afforded even by a large increase in the rolling stock.

The necessity of hauling the canal boats over the Allegheny Mountains by rail greatly restricted the capacity of the entire system, as only about 1,680 tons could be handled each 24 hours, thus limiting the traffic to about half a million net tons in 300 working days, and to that extent neutralizing the ultimate efficiency of the entire sys-

tem and increasing the cost, so that within a score of years it was supplanted by the direct rail line, with a tunnel opened in 1854 over the mountains. Of the original main line David Stephenson said in 1837: "I travelled from Philadelphia to Pittsburgh, 395 miles, in 91 hours, or at an average rate of 4.34 miles an hour, of which 118 miles were on railroads and 277 by canals. The through charge was three pounds sterling, or four cents per mile." In his review of this work, its engineer, Mr. Solomon W. Roberts, said: "We were striving to build a great public work which should endure for generations and as it turned out it was superseded by something better in about twenty years." The solution of the transportation problem is to segregate the low grade, bulky tonnage and convey it upon restored and modernized waterways under local control, as is being done in New York, Illinois, Michigan and other states to a limited extent and can be done in Pennsylvania under a liberal policy of administration, divorced from the restraining influence of a divided jurisdiction which invariably retards development.

General Benefit of the Early State Works

Although Pennsylvania expended many millions in the construction of artificial waterways, independent of the large sums raised by private corporations, the results secured were believed to be ample justification as set forth by His Excellency, Governor George Wolf, in his last annual message of 1835: "These works were endorsed by a convention held in Harrisburg in August 1825, composed of delegates from 46 counties, when resolutions were passed in favor of 'opening an entire and complete communication from the Susquehanna to the Allegheny and Ohio, and from the Allegheny to Lake Erie by the nearest and most practicable route.' To connect this system with the seaboard, the overland railroad between Columbia and Philadelphia, 81.6 miles in length, was opened in October 1834, after the 'main line' of the canal had been completed, and was operated by the State with profit, and during the same month on the completion of the Portage Railroad over the Allegheny Mountains, an emigrant's boat from the North Branch of the Susquehanna passed over the route to St. Louis."

Governor Wolf said: "The State has now 720 miles of public improvements, which in point of extent, execution and prospective usefulness, may challenge a comparison with any other structure known to modern times .....They are so located as to penetrate those sections of the Commonwealth which give the greatest promise of successful commerce .....and to develop the still latent resources. The whole cost, when all the lines are completed, will amount to the sum of $22,114,915.41, but when it is known that these

expensive works were constructed by the state in her own defense, to preserve her commerce from the grasp of powerful rival neighbors, and that her great chain of internal improvements has added incalculable millions to her present wealth and resources, the marvel will cease.

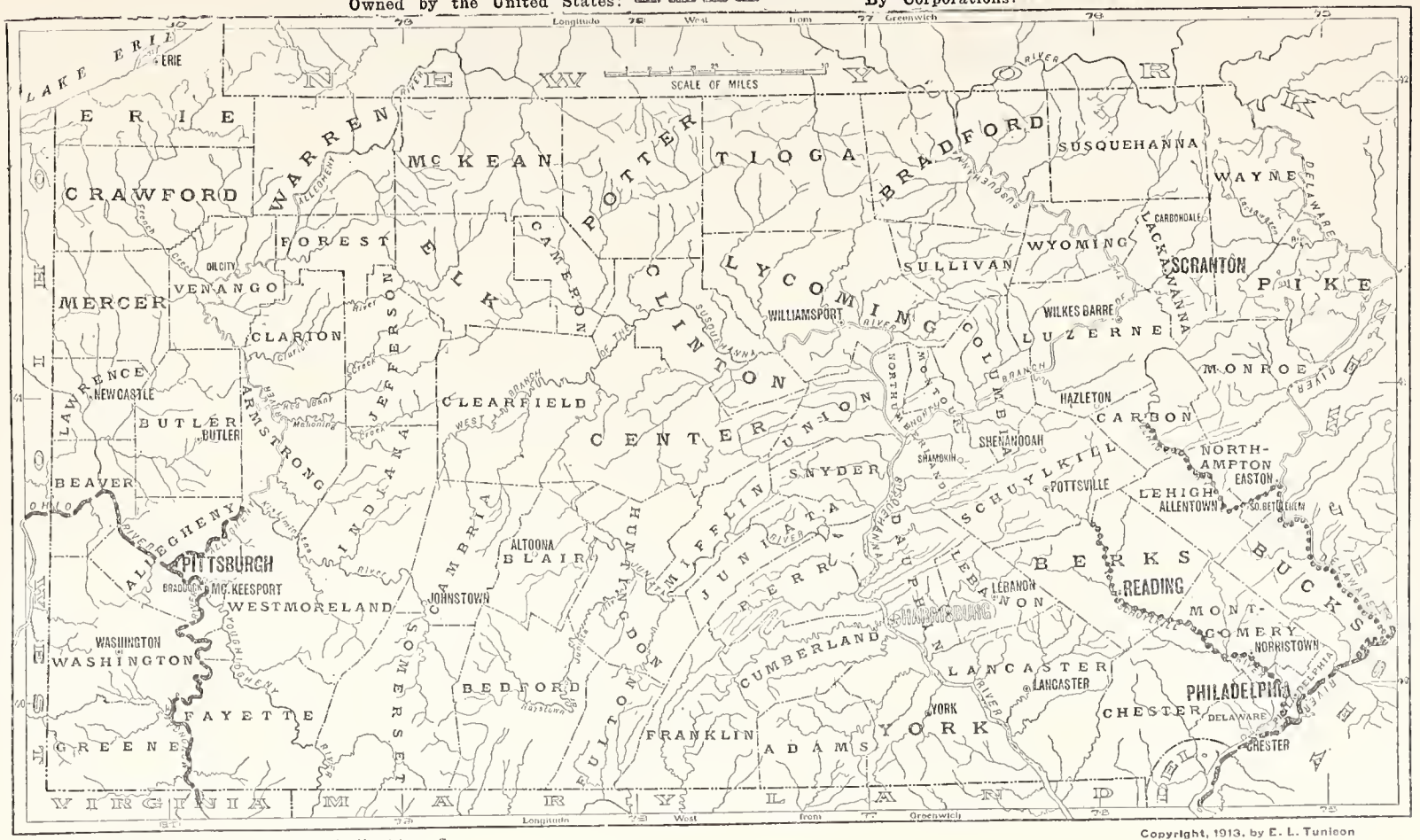
"It was for a long time considered a doubtful experiment and its eventual completion may well be regarded as a strong exemplification of the unlimited extent to which the achievements of a patriotic, enterprising people .....may be carried. Having gained this great and all important object, if it were possible that she should be prevented from realizing a single dollar in the shape of tolls for her improvements, her true interest would nevertheless have been advanced to an extent immeasurably beyond their cost." These predictions in ante-railroad days were soon dispelled by the rapid growth of population in the Ohio basin, when the problem of controlling the trade against rival interests over better routes became paramount, and the state was compelled to direct its effort to the retention of this traffic, for the maintenance of its great railways to the seaboard from the Lakes and the Ohio, by the control of the tributary lines reaching to Chicago and Cincinnati and even St. Louis.

It is not possible in these limits to trace the wonderful sagacity with which this great system has been developed, but the foresight of its early officials and their appreciation of the value of the improvement of the Ohio River are well worthy of note after so many years of delay in their accomplishment. The cause of this delay is traceable to the division of jurisdiction, the inability of any single corporation to finance so large an internal improvement and the great difficulties and delays incident to the securing of national appropriations, because of the numerous demands for similar work from all parts of the federal domain. Although more than a century has passed since the Ohio River became an important line of communication, the improvements proposed for even a 6-foot navigation are not yet realized. For a summary of these efforts see the section on Internal River Improvements, under Governmental Jurisdiction.

EXISTING LINES OF NAVIGATION
FEDERAL AND CORPORATE

Plate III

Owned by the United States: — — — — — — — — By Corporations: ○○○○○○○○○○○○



Water Supply Commission of Pennsylvania, Harrisburg, Pa.

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CHAPTER IV

CORPORATE CANALS

Preceding and contemporaneous with the activity of the state in canal construction, corporations were industrious in building similar works. The most important of these private lines were built to penetrate the anthracite field to bring the coal to the seaboard; while others were constructed as feeders or auxiliaries to state canals. Soon after the sale of the state system of canals to the railroad companies they were transferred to various subsidiary canal companies organized by the railroads.

One hundred and two canal and navigation companies were incorporated, all but one being by Special Act of the Legislature, previous to the passage of the General Corporation Act of April 29, 1874, while eight foreign corporations were given the right to build or operate lines in Pennsylvania. Some of these companies were formed for the purpose of building dams and floating logs down the streams and did not improve navigation to such an extent as to make them useful for general transportation purposes.

Table No. 5 gives a list of the canal and navigation companies, showing date of incorporation and purpose. Twenty-five supplemental acts to the incorporation of a single canal company appear in the records of as many legislatures, and the many changes in franchise rights and ownership involve a tangled story which is difficult to unravel. Some were given a great diversity of rights, including insurance business, the supply of water, and the maintenance of turnpikes.

TABLE No. 5. *Alphabetical List of Canals and Navigation Companies Chartered by the Legislature of Pennsylvania*

No.	Corporate Title.	Date of Charter.	Purpose.
1	Allegheny & Conewango Canal Co., ...	April 16, 1827, ...	To make slackwater or canal on Conewango Creek in Warren County and down Allegheny River to French Creek.
2	Allegheny Navigation Co., ...	March 29, 1856, ...	To construct dams and slackwater or canals in Allegheny River and Potato Creek in McKean and Potter counties.

TABLE No. 5. *Alphabetical List of Canals and Navigation Companies Chartered by the Legislature of Pennsylvania—Continued*

No.	Corporate Title.	Date of Charter.	Purpose.
3	Andersons Creek Public Road & Navigation Co.	March 28, 1859, ...	To build road aloug and dams in Andersou Creek and its branches in Clearfield Couuty for floating logs.
4	Atlantic Navigation Co., ...	April 14, 1863, ...	
5	Atlantic & Pacific Road & Navigation Co.	March 18, 1851, ...	
*6	Bald Eagle & Spring Creek Navigation Co.	April 14, 1834, ...	To construct canal or slackwater along Bald Eagle and Spring creeks to Milesburg and Bellefonte.
7	Bald Eagle Valley Harbor Co., ...	April 14, 1863, ...	To construct a harbor at junction of Bald Eagle Valley Railroad with Bald Eagle Cross Cut Canal near Lock Haven.
8	Beaver Canal Co., "President & Managers of."	January 27, 1819,.....	To construct slackwater on the Beaver River.
9	Big Run of Beech Creek Navigation Co.	July 19, 1866, ...	
10	Birch Island Run, ...	July 19, 1866, ...	
11	Blaek Lick Navigation & Improvement Co.	June 19, 1871, ...	
12	Bowmans Creek Navigation Co., ...	June 2, 1871, ...	
13	Brandywine Creek Canal & Lock Navigation Co.	April 10, 1793, ...	To build canal on both branches and on main Brandywine Creek.
*14	Chesapeake and Delaware Canal Co. (Maryland corporation).	February 19, 1801,....	To remove obstructious from Susquehanna River down to Maryland line. This eompany was authorized by Maryland to build canal between Susquehanna and Delaware rivers.
15	Chesapeake & Ohio Canal Co., ...	February 9, 1826,....	To construct canal from headwaters of Potomae over the divide and down to head of steamboat navigation on Ohio River, or some one tributary.
16	Clarion River Navigation Co., ...	May 23, 1854, ...	To improve uavigation on Clarion River, its East and West branehes and Little Toby Creek by clearing channel and creeting dams.
17	Clinton Couuty Water Course Co., ...	April 18, 1854, ...	To form a channel or watercourse from West Branch Susquehanna River to a connection with the Cross Cut Canal.
18	Clinton & Potter Counties Navigation.	April 13, 1868, ...	
*19	Codorus Navigation Co., ...	April 12, 1825, ...	To construct canal or slackwater on Codorus Creek from mouth to forks three miles above York.
20	Conecocheague Navigation Co., ...	February 7, 1803,....	To open for navigation the Conecocheague Creek from Chambersburg to Maryland line.
21	Conestoga Lock & Dam Navigation Co.	March 17, 1896, ...	To coustruct improved navigation on Conestoga Creek.
*22	Conestoga Navigation Co., ...	March 3, 1825, ...	To construct canal or slackwater on Conestoga Creek from mouth to Lancaster.
23	Conestoga Slackwater Navigation Co.,..	March 28, 1820, ...	To construct slackwater navigation on Conestoga Creek from mouth to Lancaster.
24	Conewago Canal Co., ...	April 10, 1793, ...	To improve the Susquehanna River from Wrightsville to Middletown and to build a canal around Conewago Falls. State appropriated $27,250.
25	Connellsville Navigation Co., ...	March 16, 1819, ...	
26	Conuellsville & West Newton Navigation Co.	April 30, 1844, ...	To construct slackwater from West Newton to Connellsville on the Youghiogheny River.

TABLE No. 5. *Alphabetical List of Canals and Navigation Companies Chartered by the Legislature of Pennsylvania—Continued*

No.	Corporate Title.	Date of Charter.	Purpose.
27	Cook's Run Navigation & Public Road Co.	April 7, 1868, ...	
28	Delaware Canal Co., ...	April 30, 1844, ...	To purchase Delaware Division Canal from State for $1,650,000.
29	Delaware Canal Co., ...	April 30, 1844, ...	
30	Delaware Division Canal Co., ...	April 21, 1858, ...	
*31	Delaware & Hudson Canal Co., ...	March 13, 1823, ...	To construct slackwater and later a canal up Lackawaxen River.
32	Delaware & Raritan Canal Co., ...	April 6, 1835, ...	
33	Delaware & Schuylkill Canal Co., ...	April 10, 1792, ...	To construct canal connecting Delaware and Schuylkill rivers in southern part of Philadelphia County. State to subscribe to 1,500 shares.
*34	Erie Canal Co., ...	March 7, 1843, ...	To construct canal from Erie to mouth of Beaver River and to use French Creek feeder.
35	Fishing Creek Navigation Co., ...	April 14, 1834, ...	To make Fishing Creek navigable in Centre County by building locks and dams.
36	Frankliu Canal Co., ...	April 27, 1844, ...	To take over from the State the Franklin Division and to complete and operate same. Later to build railroad instead of completing canal.
37	Harrisburg Canal Co., ...	March 18, 1814, ...	To build canal from Second Mountain to Harrisburg, along east side of Susquehanna River.
38	Harrisburg Canal, Fire Insurance & Water Co.	March 27, 1823, ...	To build canal on east side of Susquehanna River from Second Mountain to and through Harrisburg to mouth of Paxton Creek.
39	Hunt's Run Navigation Co., ...	December 19, 1863,....	
40	Inland Navigation Co., ...	May 9, 1871, ...	
41	International Navigation Co., ...	May 4, 1871, ...	
*42	Junction Canal Co. (New York corporation).	April 28, 1852, ...	To connect with North Branch Susquehanna River Extension.
43	Juniata Navigation Co., ...	January 18, 1840, ...	To construct canal or slackwater up Raystown Branch Juniata River to mouth of Yellow Creek.
44	Lackawanna Navigation Co., ...	February 5, 1817,....	To build canal on Lackawanna Creek.
45	Lancaster & Susquehanna Slackwater Navigation Co.	April 1, 1837, ...	To purchase property of Conestoga Navigation Co.
*46	Lehigh Coal & Navigation Co., ...	February 13, 1822,....	To build dams and enlarge and deepen Lehigh River up to Great Falls. Later to build railroad.
47	Lehigh Navigation Co., ...	February 27, 1798,....	To remove obstruction from Lehigh River up to Great Falls.
48	Lehigh Navigation Co., ...	March 22, 1814, ...	To erect slackwater navigation on Lehigh River from one end to the other and to use the water power thereof. State to subscribe $60,000 of stock.
49	Little Anderson's Creek Navigation Co.	August 24, 1864, ...	To improve Little Anderson Creek in Clearfield County.
50	Little Clearfield Creek Navigation Co.,	May 8, 1854, ...	To clear Little Fishing Creek for rafting of lumber.
51	Mahanoy Navigation Co., ...	March 22, 1827,.....	To make canal or slackwater navigation on Little and Big Mahanoy creeks and Zerbe Run, with right to substitute railroad.
52	Mahoning Navigation Co., ...	April 1, 1845, ...	To make slackwater in Mahoning Creek in Indiana and Jefferson counties.
53	Mahoning Navigation Co., ...	April 2, 1854, ...	To clear Mahoning Creek, Canoe Creek, Big Run, Stamp Creek and East Branch of obstructions and to erect dams and locks for navigation.

TABLE No. 5. *Alphabetical List of Canals and Navigation Companies Chartered by the Legislature of Pennsylvania—Continued*

No.	Corporate Title.	Date of Charter.	Purpose.
54	Monongahela Navigation Co., ...	March 24, 1817,.....	To build certain dams on Monongahela River to make slackwater to mouth of Cheat River. State to subscribe to $130,000 of stock.
*55	Monongahela Navigation Co., ...	February 18, 1836,....	To make slackwater on Monongahela River to Virginia line and to use water power. State subscribed to $125,000 of stock.
56	Montour Navigation & Improvement Co.	April 12, 1859, ...	To improve navigation on Lycoming Creek and such of its tributaries as have been or may be declared public highways.
57	Muddy Creek Navigation Co., ...	April 16, 1845, ...	To open canal or slackwater on Muddy Creek, York County.
*58	Muncy Canal Co., ...	April 1, 1836, ...	To build canal from Muncy to the Pennsylvania Canal.
59	Neshaminy Lock Navigation Co., ...	March 26, 1814, ...	To construct lock navigation on Neshaminy Creek.
*60	North Branch Canal Co., ...	July 22, 1842, ...	To take over and complete North Branch extension from Lackawanna Creek to New York line; also to construct navigable feeders up Lackawanna River to Old Forge, or to lease or purchase the Junction Canal and to construct canal or slackwater connection with Chemung Extension Canal.
61	Northern Railroad & Navigation Co.. .	March 23, 1867, ...	
62	Northumberland Canal & Water Right Co.	April 5, 1826, ...	To build canal from North Branch to West Branch of Susquehanna River through Northumberland, with right to sell water therefrom.
63	Northwestern Navigation Co., ...	March 2, 1863, ...	To improve navigation on Little Moshannon Creek in Clearfield County from mouth to forks, about ten miles.
*64	Norwegian Creek Navigation Co., ...	April 14, 1827, ...	To build canal along Norwegian Creek in Pottsville to meet the Schuylkill Canal.
65	Octoraro Navigation Co., ...	March 20, 1819, ...	To construct slackwater transportation on Octoraro Creek.
66	Oil Creek Navigation Co., ...	March 18, 1863,.....	To construct pond freshets in Oil Creek, Venango County, for purpose of floating oil boats.
67	Paddy's Run Navigation Co., ...	July 19, 1866, ...	
68	Penn's Creek Navigation Co., ...	February 23, 1830,....	To construct canal or slackwater from mouth to New Berlin on Penns Creek, Union county.
*69	Pennsylvania Canal Co., ...	May 1, 1866, ...	To purchase from Pennsylvania Railroad Company and to operate the canal from Columbia to Hollidaysburg.
70	Pennsylvania Canal & Railroad Co., ..	April 29, 1844, ...	To purchase from State the railroads and canals from Philadelphia to Pittsburgh.
*71	Pennsylvania-Ohio Canal Co., ...	April 14, 1827, ...	To construct canal up Mahoning River.
72	Philadelphia Tidelock Canal Co., ...	April 16, 1838, ...	To build canal on west side of Schuylkill River from Fairmount Dam to Mill Creek.
73	Red Bank Navigation Co., ...	April 7, 1854, ...	To erect dams and locks for navigation in Red Bank, Sandy Lake and North Fork creeks.
74	Sandy and Beaver Canal Co. (Ohio corporation).	April 14, 1828, ...	To build canal up Ohio River from Ohio line to mouth of Beaver River or above to meet proposed canal down from Pittsburgh.

TABLE No. 5. *Alphabetical List of Canals and Navigation Companies Chartered by the Legislature of Pennsylvania—Continued*

No.	Corporate Title.	Date of Charter.	Purpose.
75	Schuylkill East Branch Navigation Co.,	February 20, 1825,....	To build canal or slackwater up Little Schuylkill River. Later to substitute railroad.
*76	Schuylkill Navigation Co., ...	March 8, 1815, ...	To construct slackwater on Schuylkill River.
77	Schuylkill & Susquehanna Canal & Lock Navigation Co.	September 29, 1791,...	To build canal between Schuylkill and Susquehanna rivers, by way of Tulpehocken, Quittapahilla and Swatara creeks. State authorized to subscribe to $300,000 of stock.
78	Schuylkill West Branch Navigation Co.	March 29, 1819,.....	To construct slackwater on West Branch Schuylkill River. Later authorized to substitute canal.
79	Shamokin Canal Co., ...	April 14, 1827, ...	To make canal or slackwater up Shamokin Creek.
80	Shenango Canal Co., ...	April 1, 1823, ...	To construct canal along Shenango River in Crawford County.
81	Sunbury Canal Co., ...	April 10, 1826, ...	
82	Sunbury Canal & Water Power Co., ...	April 5, 1855, ...	To build canal between North Branch and main Susquehanna River through Sunbury.
*83	Susquehanna Canal Co., ...	April 15, 1835, ...	To construct canal along east bank of Susquehanna River from Columbia to Chesapeake Bay. Later to build it on west side.
84	Susquehanna & Conewago Canal Co., ..	March 29, 1813,.....	To build canal around Conewago Falls of Susquehanna River.
85	Susquehanna & Lehigh Canal Co., ...	March 25, 1826, ...	To build canal or slackwater from Falls of Neshannock Creek to Lehigh River, and later to connect with the canal near Berwick.
86	Susquehanna & Patapsco Canal Co., (Maryland corporation).	April 7, 1826, ...	Gives assent of Pennsylvania to this company to build canal from Baltimore to York Haven.
87	Susquehanna & Tidewater Canal Co.,	April 14, 1845, ...	Formed by a form of partnership between the Susquehanna Canal Co. and the Tidewater Canal Co.
88	Trout Run Navigation Co., ...	February 23, 1867,....	
89	Tuscarora & Licking Creek Navigation Co.	April 7, 1864, ...	To improve Tuscarora and Licking creeks from mouth to Juniata County line, 25 miles, for passage of logs and lumber.
90	Two Lick Navigation and Improvement Co.	April 13, 1870, ...	
*91	Union Canal Co., ...	April 12, 1811, ...	Successor to Schuylkill & Susquehanna Navigation Co. and Delaware & Schuylkill Navigation Co.
92	Upper Lehigh Navigation Co., ...	March 14, 1840, ...	To improve navigation on Lehigh River around Great Falls and above same.
93	Upper Morgan's Run Navigation Co.,...	April 15, 1869, ...	
*94	West Branch Susquehanna Division Canal Co.	May 1, 1861, ...	To own, operate and acquire from the Sunbury & Erie Railroad Co. the West Branch Canal and Susquehanna Canal from Tangascootack Creek by Northumberland to mouth of Juniata River.
95	West Philadelphia Canal Co., ...	April 4, 1831, ...	To make canal around west abutment of bridge over Schuylkill River at Philadelphia. Later, State appropriated $1,200 to this company.
*96	Wiconisco Canal Co., ...	July 13, 1842, ...	To build canal along east bank Susquehanna River from Millersburg to Clarks Ferry.

TABLE No. 5. *Alphabetical List of Canals and Navigation Companies Chartered by the Legislature of Pennsylvania—Continued*

No.	Corporate Title.	Date of Charter.	Purpose.
*97	Wyoming Canal Co., ...	April 11, 1859, ...	To take over from the Sunbury & Erie Railroad Company the North Branch Canal from Wilkes-Barre down.
98	York Haven Canal Co., ...	March 26, 1814, ...	To take charge of and maintain the Conewago Canal in York County.
*99	Youghiogheny Navigation Co., ...	April 18, 1843, ...	To make lock navigation on the Youghiogheny River from mouth to West Newton.
100	Youghiogheny Slackwater Navigation Co.	April 4, 1868, ...	
101	Young Women's Creek Navigation Co.,	April 13, 1863, ...	
102	Lake Erie and Ohio River Canal Board,	Act of June 24, 1895,	To construct a ship canal along Ohio River from Pittsburgh to Beaver River and up Beaver River to mouth of Mahoning, and up that stream to Pennsylvania-Ohio state line.

Detailed descriptions of each of the canals of Pennsylvania operated under corporate ownership are given on pages 54 to 76.

Of these 102 companies incorporated in Pennsylvania, or authorized to do business in Pennsylvania, this investigation discloses the fact that only 29 ever reached the stage of operation. Through mergers and consolidations, only 21 lines of canal or improved navigation were actually built under the grants conferred. The companies which built, or operated after purchasing, lines of canal or slackwater are indicated by asterisks in Table No. 5.

STATE CANALS UNDER CORPORATE OWNERSHIP

North Branch Canal Company—Wyoming Canal Company

On May 25, 1858, six days after purchasing it from the State, the Sunbury & Erie Railroad Company sold the North Branch Canal to the North Branch Canal Company, and on June 24, 1858, the lower portion thereof, extending from Wilkes-Barre to Northumberland, was sold by the North Branch Canal Company to the Wyoming Canal Company. The remaining portion was operated by the North Branch Canal Company until in 1865 the company changed

its name to the Pennsylvania and New York Canal and Railroad Company, and it was empowered to build a railroad track on or near the towpath. The canal was abandoned, the railroad was built, and is now operated by the Lehigh Valley Railroad Company. The Wyoming Canal Company changed its name to the Wyoming Valley Canal Company in 1863, operating the line until it was merged with the Pennsylvania Canal Company in 1869.

West Branch and Susquehanna Canal Company

After its purchase of the West Branch Division of the State Canal on May 19, 1858, the Sunbury & Erie Railroad Company sold this line to the West Branch and Susquehanna Canal Company, which later was merged into the Pennsylvania Canal Company. This sale included the line extending from Tangascootack, Clinton County, through Northumberland, and thence down the main river to the mouth of the Juniata River.

Wiconisco Canal Company

The Wiconisco Canal Company, incorporated July 13, 1842, purchased the Wiconisco line from the State, before it was finished, in 1850, completing and operating it until it was merged into the Pennsylvania Canal Company. The line was operated by this merger until destroyed by the flood of 1889, abandoned on February 7, 1890, and the property sold for $30,000. This line at one period of its history was an important feeder to the main line, bringing down a large tonnage of Lykens coal.

Pennsylvania Canal Company

Following its purchase of the main line of the State Canal in 1857, the Pennsylvania Railroad Company sold its canal holdings, with the exception of the Western Division, to the Pennsylvania Canal Company, incorporated under Special Act of May 1, 1866, having operated its canal for eight years in conjunction with the railroad line. The Pennsylvania Canal Company, which was controlled by Pennsylvania Railroad interests, in 1868 consolidated with the West Branch Susquehanna Canal Company, and in January 1869 with the Wyoming Valley Canal Company, and later with the Wiconisco Canal Company. Thus the Pennsylvania Canal Company came into possession of all the lines that were formerly operated by the State with the exception of the Delaware Division, the upper North Branch Division, the Western Division, the Beaver Division and the French Creek feeder. The Western Division from

Johnstown to Pittsburgh was abandoned in the spring of 1870 and the property sold to the Western Pennsylvania Railroad Company.

Soon after its purchase the company enlarged the Susquehanna line from Columbia to Wilkes-Barre, making it six feet deep and capable of passing 260-ton double boats, and established a boat building yard at the mouth of Fishing Creek. Here boats were built to be rented to navigation companies and individual shippers. The coal trade from the Wyoming Valley field was the greatest source of traffic, the canal company having large holdings of stock of the Susquehanna Coal Company, and the endeavor of the canal company was to reduce the cost of handling this tonnage. The Juniata line was not important as the railroad carried most of the western freight, and from about 1870 the Pennsylvania Canal Company spent as little as possible to maintain it in operating condition.

For a period of about 20 years after their sale by the State these lines seem to have produced a profit over operating, maintenance and interest charges, but in 1877 the receipts fell below the expenditures. Only once thereafter (1883) did they exceed them, and the abandonment and sale of portions of the line began.

The flood of June 1889 was the greatest blow the canal lines received, and the report of the President of the Pennsylvania Canal Company for 1889 states as follows concerning the effect of this flood: "The Juniata Division from Newton Hamilton to the Rope Ferry, a distance of 56 miles, was entirely destroyed, and suffered much damage from the last point to the Junction.

"The West Branch Division was destroyed to a considerable extent throughout, and west of the Loyalsock was mostly obliterated.

"The Wyoming Division suffered very little damage.

"The Wiconisco Division, 12.5 miles in length, was destroyed.

"The Eastern Division suffered considerable damage but was restored about August 1st at a cost of $35,294.52.

"The West Branch Division was restored by September 10th at a cost of $72,846.61, as far west as Muncy Dam, but all the portion west of the Loyalsock, being 35.3 miles, has been legally abandoned for public use, and with the exception of the Lock Haven Dam and 2.25 miles of canal next east thereof, has been sold to the P. & E. R. R. Co. for $75,000.00 cash .....

"The part of the West Branch Division west of the Loyalsock and the whole of the Juniata Division have long since ceased to produce gross earnings equal to their cost of maintenance, and have been an annual loss to the company for several years, and there is no such traffic or prospect of traffic on the Wiconisco Division as will warrant the large expenditures required for its restoration, even if the company possessed the means therefor .....

"For some years past the only part of the canal, with trifling exceptions, which has produced any net earnings, or has earned the cost of its annual maintenance, has been what is called 'The Main Line,' extending from Nanticoke to Columbia, 144 miles, which has continued to transport such coal tonnage as could not, from time to time, find car, or other facilities, by railroad and in the face of the constantly increasing facilities and diminishing rate of any increase in the canal tonnage or the restoration of any tonnage to the non-earning parts of the canal."

A second severe blow was the abandonment by the Philadelphia & Reading Railroad of the Susquehanna and Tidewater Canal, in 1894. This line had been depended upon by the Pennsylvania Canal Company for an outlet to tidewater, and a large portion of its coal traffic found its outlet by this route through the Chesapeake and Delaware Canal to Philadelphia. The canal was not repaired by the owners after the flood of 1894, and another reduction in traffic on the Pennsylvania Canal followed.

The restoration of the Juniata Division, after the flood of 1889, would have cost over $300,000 and after the company refused to repair it, suits were brought by producers along the line to compel its restoration; but in 1899 legislative enactment permitted its abandonment after the State Supreme Court had upheld the company in so doing, and the line was sold for $100,000. The Bald Eagle Side Cut was sold in 1901 for $9,000, and the Lewisburg Cross Cut for $1,100. The main line to Nanticoke and the lower part of the West Branch Division were used at intervals until 1901, when the whole works were finally abandoned, under legal authority, and although the canal company still maintains its organization, it operates no canal and is disposing of its real estate and other property as opportunity permits.

The report of the President of the Pennsylvania Canal Company for 1899 states "the portions of the entire canal line during recent years exhibit a steady decline from $105,816.75 of net earnings in 1888, to a deficit of $49,302.47 in 1899. This decline is no doubt partly due to the exclusion of the canal from any navigable outlet to tidewater through the abandonment in 1893 of the Susquehanna Canal, extending from Columbia to Havre de Grace, by its owners, The Philadelphia & Reading Railroad Company, who found it no longer profitable to operate. But the more potent and continually increasing cause has been the steady decline in the cost of rail transportation and the increasing facilities which the railways are able to extend to their shippers by the multiplication of short branches and sidings, reaching every source of tonnage at one end of their lines, and every consumer's yard, wharf or factory at the other. The

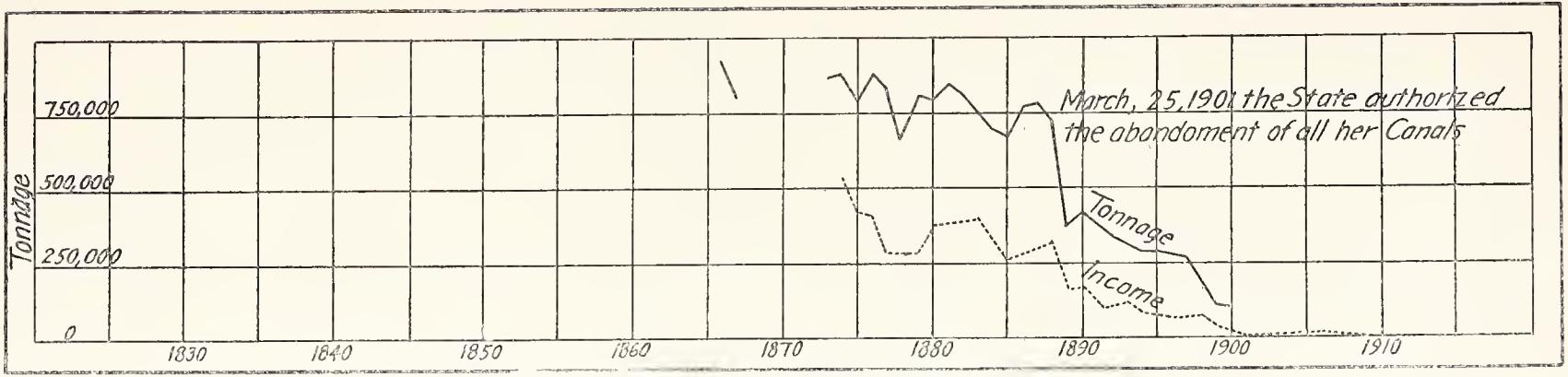
comparative decline of facilities and increase of cost on the canal have been slow and gradual, but continuous, during a series of years, and with a trifling exception in 1897 the canal has during the past six years failed to earn its current expenses of operation and has contracted a floating debt amounting to $16,747.22, exclusive of a large amount of unpaid coupons. With the steady decrease in the cost of railroad transportation effected by the use of heavier power and equipment, it will probably be but a short time before the bulk of the coal heretofore transported by your canal will be shipped by rail."

The following table shows the gross earnings of the lines of the Pennsylvania Canal Company, the number of tons transported, number of boats owned by company, operating and maintenance cost, and surplus or deficit over all expenses:

TABLE No. 6. *Annual Traffic Receipts of West Branch Canal Company, Wyoming Canal Company and Wiconisco Canal Company*

Year.	Tonnage.	Gross earnings.	Operating expenses, not including interest.	Profit or deficit, including interest on bonds or surplus..	Number of company boats.
1875,	781,708	$444,669	$240,637	+$5,671	197
1880,	861,798	368,770	177,826	—1,600	219
1885,	624,021	274,207	145,441	—46,584	284
1890,	469,084	169,095	116,273	—107,078	283
1895,	280,375	66,692	68,310	—147,466	213
1900,	103,622	38,218	49,866	—141,588	142
1905,	.....	2,296	4,811	—119,398	.....

In regard to the tolls and cost of transportation over the Pennsylvania Canal, the President of the company states in the annual report for 1874: "As was remarked in last Report, the above calculation of the cost of transportation is given as the best approximation now practicable; but it is a great exaggeration of the actual cost, because almost all of the earnings are derived from less than 200 miles of enlarged, and, therefore, profitable canal; while the cost of maintaining and operating 130 miles of additional canal which is not enlarged, and therefore not profitable, but which, if enlarged, would probably be the most profitable part of the whole, is averaged upon the tonnage. This is to say, the expense of maintaining and operating 330 miles of canal is averaged on the tonnage which is moved exclusively on about 200 miles; the remaining 130 miles having but little trade on account of its small dimensions, which restrict its use to boats of the capacity of 70 tons or less.



Showing Tonnage and Income, Pennsylvania Canal

"It has already been pointed out in these reports that with boats of that capacity, requiring for their 70 tons of cargo the same amount of labor, and nearly as much motive power as double boats carrying 260 tons, competition with other modern agents of transportation can no longer be maintained.

"It is believed that on the enlarged parts of the canal, disembarrassed from the unimproved portion, the cost of transportation, including every element whatever, except interest on the value of the canal line, cost in 1874 less than six mills per gross ton per mile, and this general estimate is checked and corroborated by the actual expense of that portion of the transportation which was performed by the company in its own boats upon the enlarged part of the canal, equivalent to 33,404,249 tons moved one mile. This was done in 58 double and 51 single boats, at the actual cost of 1.11 cents per gross ton per mile, taking the single and double boats together, and included all the tolls paid both to the Pennsylvania and other canals traversed. As the tolls or profit paid to the Pennsylvania Canal was .591 of a cent per gross ton per mile, we have .519 of a cent as the actual cost of movement. But the freight in single boats exceeded that in double boats exactly 25 per cent, besides which a considerable profit, including interest charged upon the capital invested in boats, was earned on the boat rents which is included in the above estimated *cost*. This cost would be further reduced by the exclusive use of the double boat, and still more, should the Reading Railroad Company complete the deepening of their Susquehanna Canal to six feet of water, a measure which would enable this company to increase its cargoes from 260 to 300 gross tons without any perceptible increase in the expense of movement.

"It is also evident that the cost per ton per mile would be reduced by an increased tonnage, in far greater proportions than upon a railroad, because upon the latter each new ton added to the tonnage being the cause of a specific wear and tear of materials, only adds to the net profits the freight earned by it, *less* that wear and tear. But upon the canal there is no additional wear and tear, and the cost of maintaining and operating the canal being once met, the whole freight earned upon each additional ton must be added to the net receipts.

"But while these facts are incontestible, it is equally true that, in order to realize all the advantages of them, it is necessary that a canal line should possess actual independent communication with the source of tonnage at one end of its line, and with its market or destination, either directly or through navigable waters at the other, an advantage which is possessed by very few canals in this country

to the extent attainable on any rail lines by the construction of a few short branches or extensions.

"Whether this company's line on the Juniata is not a case where such advantages are virtually possessed, is a subject very material to the questions regarding it which will soon press for decision." (Eighth Annual Report, The Pennsylvania Canal Company, Year ending December 31, 1874).

Delaware Division Canal Company

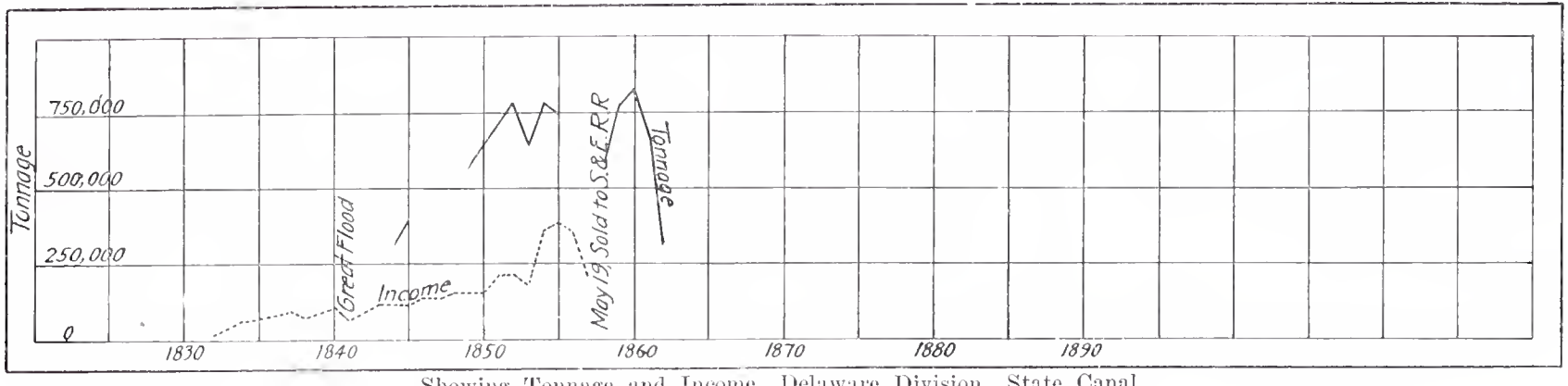
The Delaware Division Canal Company, incorporated July 14, 1858, took over the Delaware Division Canal from the Sunbury & Erie Railroad Company, and operated the line for nine years, but the operation was not successful owing to trouble with the Lehigh Coal & Navigation Company controlling a portion of the route, lack of facilities, etc., so that this company did not share in the prosperity common to the other coal-carrying lines during the Civil War. The enlargements started by the State were completed in 1864, giving the canal capacity to handle 100-ton boats, but even then tonnage continued to fall off, and in 1866 all the properties of the Delaware Division Canal Company were leased to the Lehigh Coal & Navigation Company for 999 years.

TABLE No. 7. *Tonnage of Delaware Division Canal Company*

Year.	Total tonnage, exclusive of lumber.	Coal.
1858,	587,741	512,512
1859,	770,065	.....
1860,	808,662	639,323
1861,	681,425	.....
1862,	325,001	.....

The present dimensions of the Delaware Division Canal are: width at top 44 feet; at bottom 24 feet; depth 6 feet; locks 90 feet by 11 and 90 by 22. The line is usually open about nine months in the year. In 1909 the capital stock of the Delaware Division Canal Company was $1,633,350, bonds $800,000, practically all of the stock being owned by the Lehigh Coal & Navigation Company. A total of 171 boats were then operated on the line, none of which are owned by the company. The rent on lease by the Lehigh Coal & Navigation Company was $35,466.

Plate V



Showing Tonnage and Income, Delaware Division, State Canal

Building Canal Boats for the Schuylkill Canal, at Highspire, on the Susquehanna River

CANALS BUILT AND OPERATED BY CORPORATIONS

Schuylkill Navigation Company

The Schuylkill Navigation Company was incorporated in May 1815, having been granted by Act of Legislature of March 15, 1815, a perpetual charter to develop a waterway on the Schuylkill River. The original cost was estimated at $500,000, of which the State subscribed $50,000.

Like the Lehigh River, the Schuylkill early attracted the attention of those interested in opening the interior of the state through improved navigation. But unlike the other canals in that section, the principal object was not the transportation of coal, but to bring to Philadelphia the agricultural and forest products of the valley, and also the traffic of the Union Canal, upon which some work had been done about this time.

This company built 108 miles of improved navigation on the Schuylkill River from Philadelphia to Mill Creek, near Pottsville, Schuylkill County, 50 miles being slackwater and 58 miles canal, effected by 71 locks overcoming 619 feet of rise. The line is still considered as in operation, being leased to the Philadelphia & Reading Railway Company which maintains the charter.

Work was begun in 1816, and after some financial difficulties, through which the company was carried largely by the aid of Stephen Girard, was officially opened October 1, 1825, one section having been put in service in 1818. The total cost amounted to $2,200,000, far more than had been anticipated. The canal was 4 feet deep and 36 feet wide, passing boats of 55 tons capacity. By 1827 it had become apparent that the coal trade was to be an important source of income, the total receipts for that year being $58,149.74, of which $33,317 was from coal.

From the date of its completion until 1842, when an era of competition with the Philadelphia & Reading Railway Company came, and later between 1855 and 1870, when the navigation line was leased to the railroad, the company prospered exceedingly. In 1865 the receipts were the largest in its history,—$1,617,339.31. During these periods of prosperity dividends were regularly paid, ranging from 6 per cent to 24 per cent, and shares of stock (par value $50) sold as high as $175, the stock being greatly sought for investment by charitable institutions, colleges, etc. In 1833 there were 580 boats engaged in traffic on this line; in 1842 there were 800.

Storage reservoirs were built between 1834 and 1839 for maintaining the water supply during the dry season, and in 1846 the canal was increased from 4 to 6 feet in depth and from 36 feet to 70 feet in

width, thus permitting an increase in capacity of from 55 to 180 tons in the boats that could be carried. In 1850 a flood did much damage and cost the company nearly $1,000,000 for repairs.

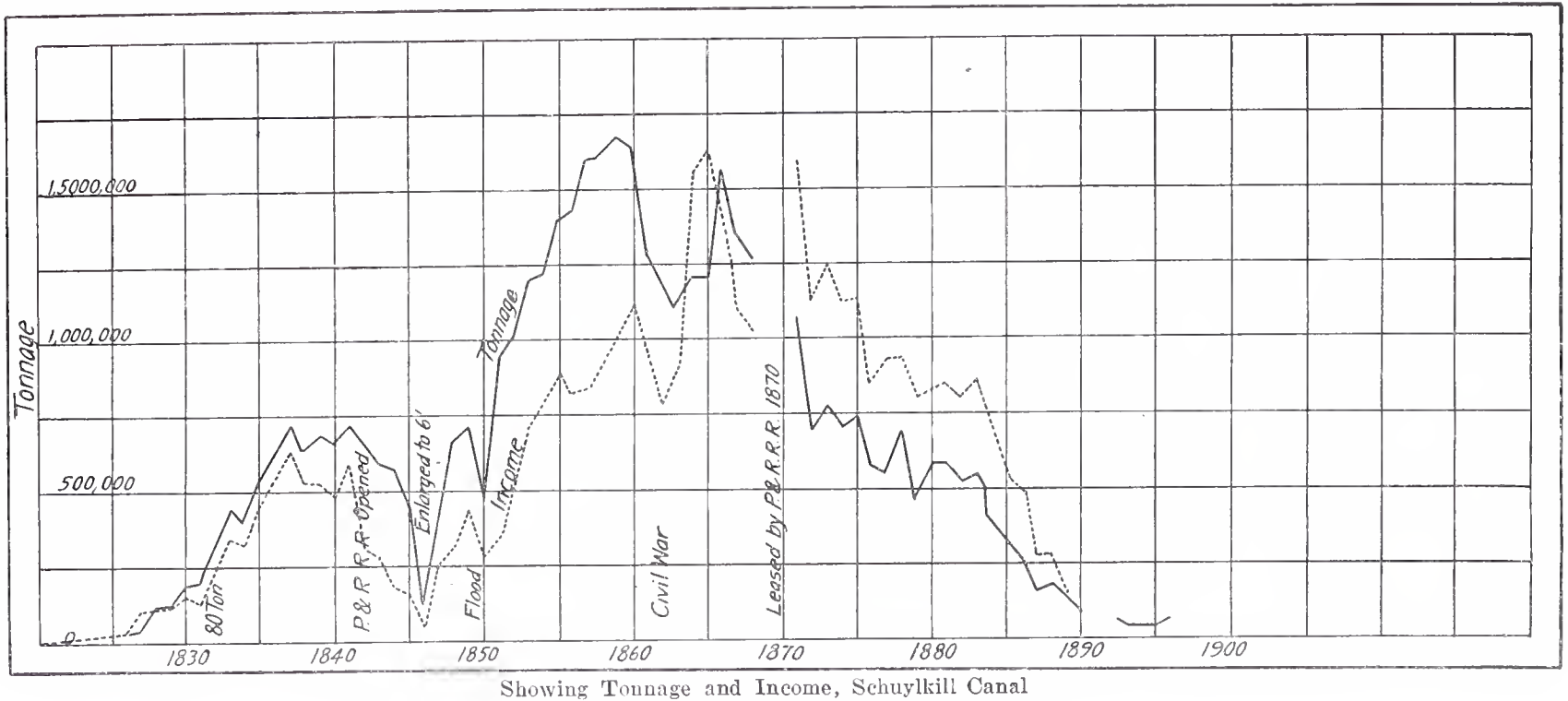
The time required for the trip from Mt. Carbon to Philadelphia and return was from seven to nine days. The company never engaged in the transportation business as did the Lehigh Coal & Navigation Company and the Delaware & Hudson Canal Company, but simply maintained a highway for boats owned by corporations and individuals, charging tolls for the use thereof. At first the toll on coal was $1.68 per ton from Mt. Carbon to Philadelphia; reduced in 1839 to $1.00; in 1842 to 54 cents or 0.5 cent per ton per mile, and during the period of railroad competition the toll was cut to 39 cents. Later when the canal and railroad came to an agreement the toll was raised to 60 cents per ton, and then to 70 cents, and since its lease to the railroad it has been raised to $1.70. Much of the coal was shipped beyond Philadelphia, going down the Schuylkill Navigation and thence up the Delaware River and across New Jersey by the Delaware & Raritan Canal, the whole trip occupying, in 1839, seven days.

As shown by table No. 8, this line handled a greater coal traffic than any of the other anthracite canal companies:

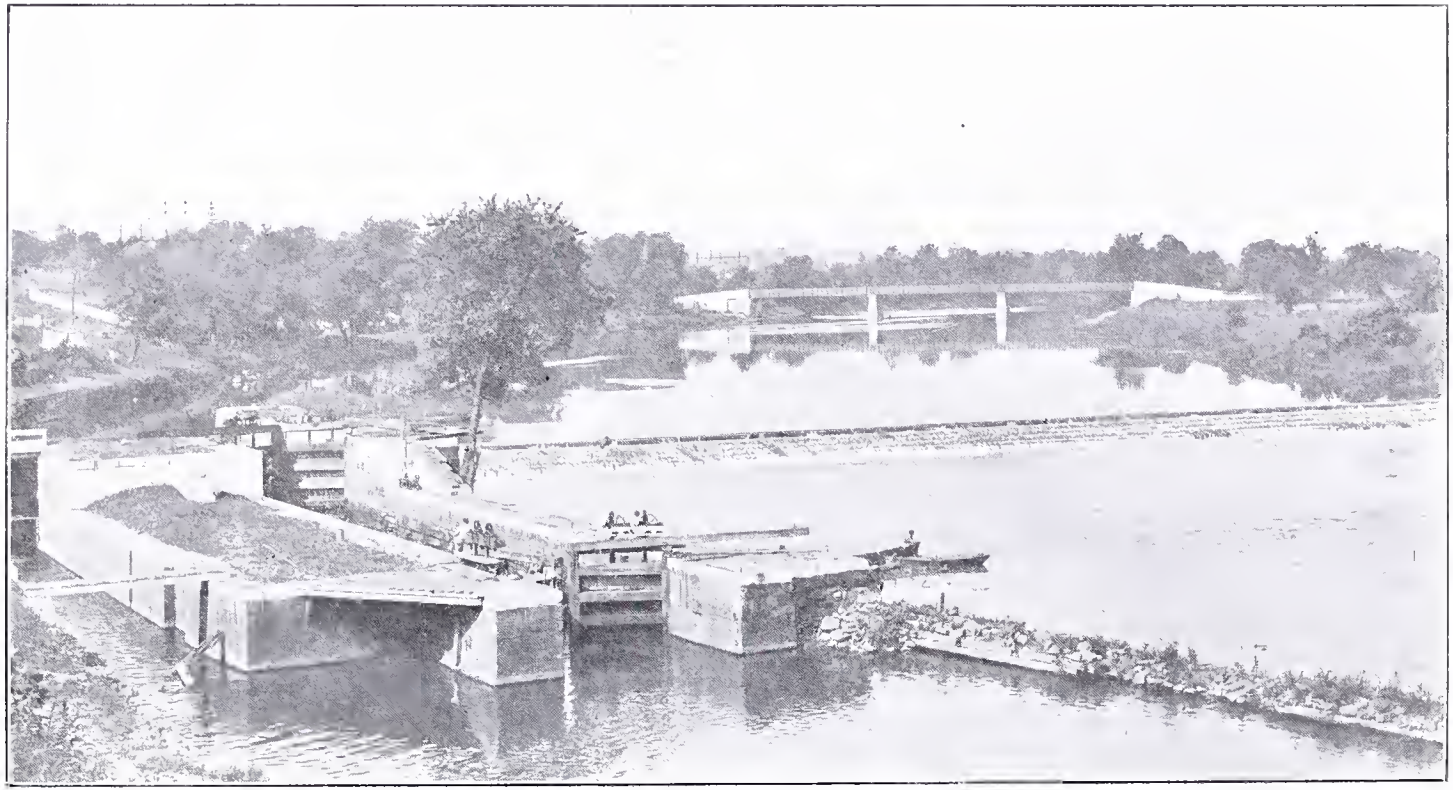
TABLE No. 8. *Comparison of Anthracite Tonnage of Coal Carrying Canals*

Company.	Year.		
	1839	1842	1843
Schuylkill Navigation,	442,360	491,602	447,058
Lehigh Canal,	220,645	271,374	267,734
Delaware & Hudson,	122,300	204,253	227,605
Union Canal Co., via Schuylkill Canal,	248	.....	.....
Reading Railway from the Schuylkill region,	.....	49,398	229,015

On July 12, 1870, the Philadelphia & Reading Railway Company leased and took possession of this line, guaranteeing a yearly rental of $665,000, which was gradually reduced as the Navigation Company debts were paid, until in 1896 it was only $9,236.18. The railroad company immediately established a transportation line on the canal, but it was not successful and was discontinued in 1888. The new owners allowed the line to carry less and less coal, merely diverting to it that which the railroad could not handle, and the earnings (of the canal) dropped from $1,077,079 in 1870 to $661,540 in 1872, declining gradually to $53,404 in 1896, when entries ceased, the railroad being able to bear the deficit between the receipts and the amount of the lease and expenses, on account of the withdrawal of competition. The present capital stock is $3,962,262, indebtedness is $2,602,950, and the company owns 39 of the 40 boats in the service.



Showing Tonnage and Income, Schuylkill Canal



Dam and Lock, Schuylkill Canal, at Perkiomen Junction (Present Condition)

The line is still in operation, from Port Clinton to Philadelphia, but doing only a small business. An application to the State Legislature for permission to abandon it, made a few years ago, was not granted. Water is leased to mill owners and manufacturers for water power, at points along the line, where the fall between the canal and the river is utilized. The present dimensions are: width at top 58 to 300 feet; bottom 40 to 45 feet; depth 6.0 to 6.5 feet; locks 110 feet by 18 feet. The line is usually open about eight months in the year.

Total receipts for year ending June 30, 1909, were $29,741.51, and the total charges were $661,468.01, giving a deficit for the year of $611,726.50. Gross traffic for the year ending June 30, 1909, was 78,464 tons. The total cost to 1909 of canal and fixtures was $11,018,825.48, and the total capital stock issued $3,962,250, while bonds and unfunded debt amount to $19,873,411.87.

TABLE No. 9. *General Statement of the Business of the Schuylkill Navigation Company*

Year.	Total Tonnage.	Total Toll.	Amount on Rents.
1820,	.....	$1,202 16	.....
1825,	.....	15,775 74	$4,700 00
1830,	180,755	148,165 95	13,800 00
1835,	535,194	433,643 64	17,898 54
1840,	658,544	468,380 08	11,746 23
1845,	467,742	135,147 19	17,336 98
1850,	458,049	244,056 47	22,231 35
1855,	1,396,493	848,580 79	27,033 55
1860,	1,651,416	1,089,773 54	38,693 76
1865,	1,200,652	1,617,339 31	26,727 30

TABLE No. 10. *Earnings on the Schuylkill Navigation under the Reading Railroad Management*

Year ending November 30th.	Total tonnage.	Schuylkill Canal. Total earnings.	Total earnings from canal business.
1871,	.....	$1,077,079	$1,599,521
1875,	.....	737,659	1,129,563
1880,	706 066	573,133	$17,983
1885,	683,562	307,590	567,485
1890,	182,992	81,222	.....
1895,	.....	43,959	.....

TABLE No. 11. *Expenses on the Schuylkill Canal under the Reading Railroad Management*

Year ending November 30th.	Receipts over cost of working.	Taxes and other charges.	Results of operation of canal.	Results of Schuylkill Canal and Schuylkill Navigation Line.
1871,	$746,641	$728,379	+$18,262	—$15,446
1875,	539,867	669,937	—130,069	—125,716
1880,	403,180	627,669	—224,489	—191,124
1885,	170,221	614,512	—444,291	—443,044
1890,	.....	21,986	.....	.....
1895,	.....	9,236	.....	.....

Union Canal Company

The Union Canal, which connected the Schuylkill River at Reading, by way of Tulpehocken, Quittapahilla and Swatara creeks with the Susquehanna River at Middletown, is believed to have been begun prior to any other work of the kind in the United States. The idea of connecting the Schuylkill and Susquehanna rivers was first projected by William Penn in 1690, and the route he suggested was practically that followed by the canal. The first survey was made by a Committee of the American Philosophical Society in 1770, in connection with a larger scheme to connect Philadelphia with the Great Lakes and the Ohio River, reported upon at an earlier date.

In 1791 and 1792 the Pennsylvania Assembly incorporated by Special Act two companies to improve navigation along the lines of this survey, namely, the "Schuylkill and Susquehanna Navigation Company" and the "Delaware and Schuylkill Navigation Company." The object of the latter was to build a canal up the Schuylkill to Reading with a connection with the Delaware to the north of the city by way of Germantown, while the former company planned to connect Reading, on the Schuylkill, with Middletown, on the Susquehanna River. The former company was capitalized at $400,000 and the latter at $450,000, and both companies soon started work, the Delaware and Schuylkill Navigation building several miles of canal between the Delaware and the Schuylkill, and the Schuylkill and Susquehanna Navigation Company constructing six or eight miles of line near the summit level, between the Tulpehocken and Quittapahilla valleys. Financial troubles came after 15 miles of canal had been built, at a cost of $450,000, and the companies were reorganized and merged in 1811 under the name of the "Union Canal Company."

The War of 1812 put a stop to operations, which were not resumed until 1821, at which time the company devoted its attention to the Reading-Middletown line, and instead of the mere ditch originally

dug a larger canal was undertaken, which was finally completed throughout the entire distance in 1827. The line between the Delaware and Schuylkill was subsequently purchased by the Philadelphia & Reading Railway and used as a location for its tracks.

The canal was opened for traffic in the spring of 1828, and was 77 miles long, 36 feet wide at the top and 4 feet deep, the total lift being 519.5 feet, effected by 93 lift and 2 guard locks. A feeder from Swatara Creek was also built between 1828 and 1832 and later turned into a navigable branch 22 miles long, extending into the Pine Grove coal region of southern Schuylkill County. The canal was found to be too small to carry the larger boats from the Pennsylvania and Schuylkill canals, which lines had been built during the same period and the traffic was disappointing. The Union Canal locks could pass only boats of 25 tons, while the state canals could pass boats of 80 tons, and traffic was going down the Susquehanna and Tidewater Canal and through the Chesapeake and Delaware Canal to Philadelphia, instead of across by way of the Union Canal. It was not until 1850, however, that a general enlargement was undertaken, at which time provision was made for the passage of 80-ton boats.

Trouble was experienced from the first in the limestone country through which it passed, with bottom leaks, and sections were planked and finally puddled before the leakage was stopped. Difficulty was also found in maintaining a sufficient water supply for the summit level, and it was necessary to pump water, by water power and steam pumps, from Swatara and Quittapahilla creeks, raising the water 95 and 45 feet respectively at the different pumping stations. This difficulty was only partly overcome by a lowering of the summit level from the height proposed in the original plans by the construction of a tunnel near Lebanon. This tunnel, still in existence, is an interesting relic of American engineering, having been, so far as known, the first tunnel constructed in America. The second, likewise in Pennsylvania, was on the line of the Allegheny Portage Railroad on the Conemaugh River above Johnstown. Three reservoirs were also constructed, covering in all over 100 acres and from 20 to 30 feet deep, on streams north of the canal to impound the freshet flow for utilization on the summit level.

In order to assist in these improvements, which would bring more traffic to its line, the Schuylkill Navigation Company agreed to pay $70,000 annually to the Union Canal Company, the assumption being that this expenditure would be justified by the tolls on traffic coming from the latter company's line. The cost of this improvement and the failure to realize the increased traffic threw the company into financial embarrassment, and from 1858 to the date of its sale the line was operated by trustees for the bondholders. In 1852 the

entire capital stock of the Union Canal Company was $3,169,000, $2,750,000 being common and $419,000 preferred, while the average annual operating expense was approximately $50,000.

The Pine Grove Branch, over which coal and timber in considerable quantities had come to the main line, was abandoned in 1862, and later almost completely destroyed by flood. The entire line had never carried the traffic expected, although at one period it was transporting much of the Pennsylvania Canal trade to and from Philadelphia. In 1885 the canal was sold by the Sheriff of Philadelphia County to the Schuylkill and Middletown Canal Company, which company was dissolved by order of the Common Pleas Court of Bucks County in November of that year, and the property sold to the Eastern Real Estate Company in 1891, the line having ceased to operate in 1885. The total cost had been about $6,000,000. This unfortunate collapse might have been frustrated had the original dimensions been large enough to pass the contributory tonnage.

Table No. 12 shows the business of the Union Canal from its opening to its abandonment:

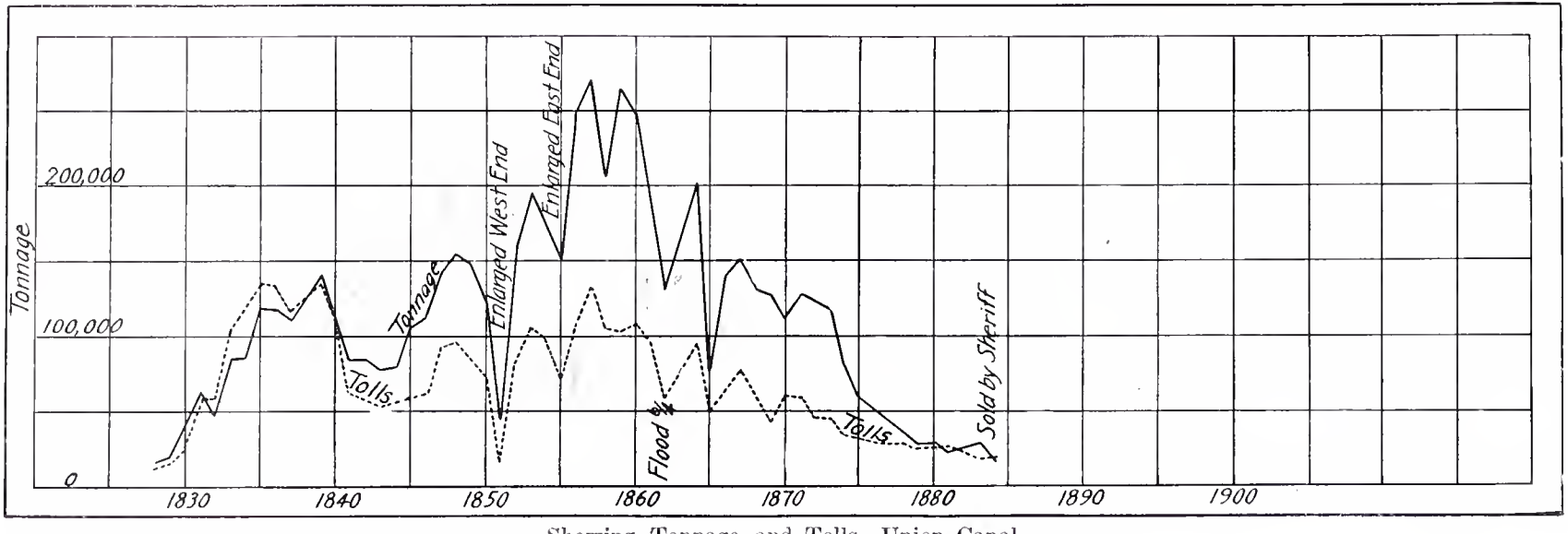
TABLE No. 12. *Comparative Statement of the Business of the Union Canal from 1830 to 1885*

Year.	Tons.	Tolls received.	Expenses for operation and maintenance.	Net earnings.	Average rate per ton.
1830,	41,694	$35,133	.....	.....	$0.855
1835,	118,978	135,254	.....	.....	1.137
1840,	115,292	110,855	.....	.....	0.961
1845,	102,593	60,036	.....	.....	0.585
1850,	128,438	76,269	.....	.....	0.594
1855,*	151,571	72,915	$41,376 68	.....	0.481
1860,	246,871	108,080	56,270 25	.....	0.419
1865,	76,061	48,505	47,226 00	$1,279	.....
1870,	110,760	59,952	55,750 00	4,202	.....
1875,	58,495	31,596	29,684 00	1,912	.....
1880,	29,853	26,997	22,496 00	4,501	.....
1885,†	.....	.....	.....	.....	.....

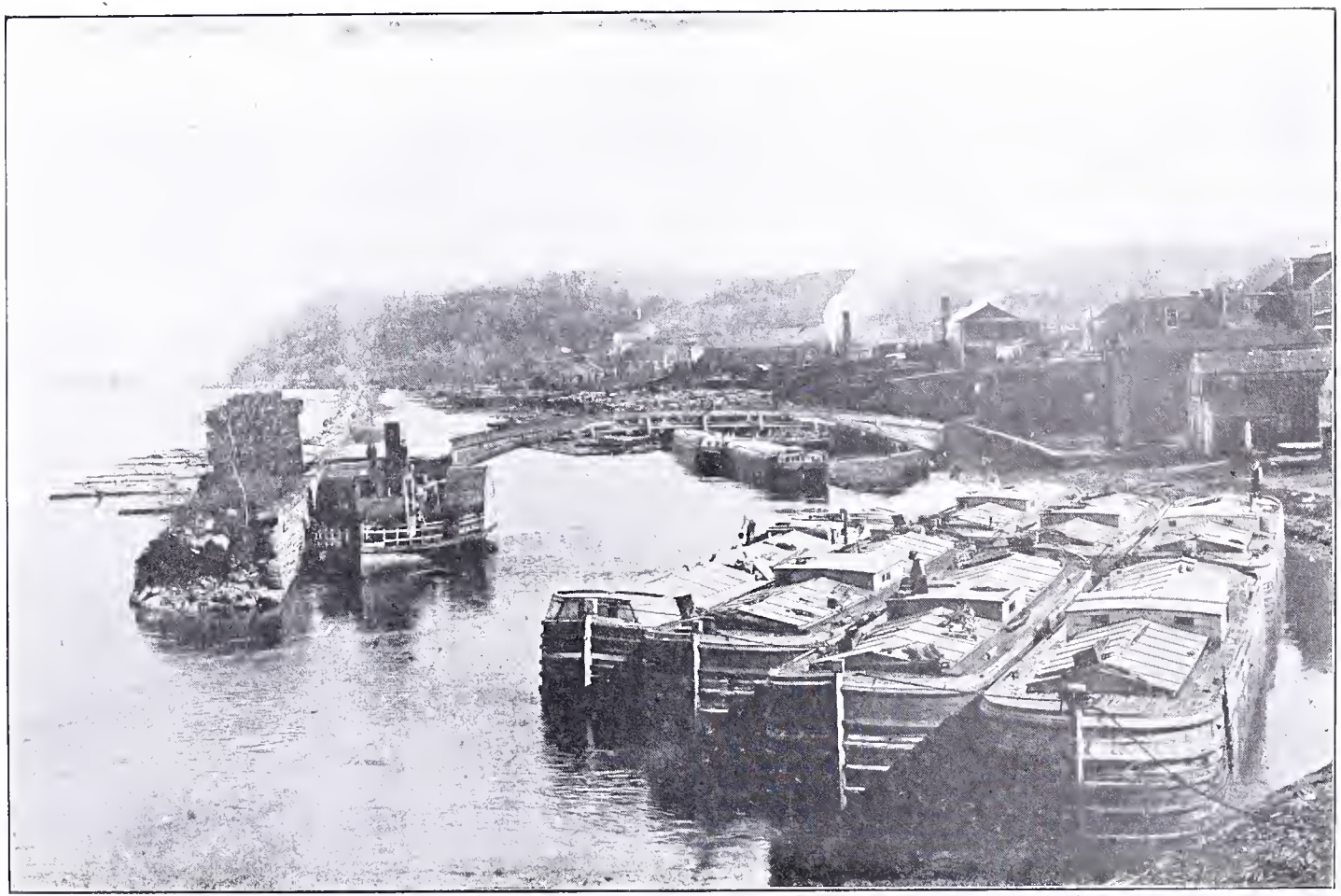
*Open only from Lebanon to Middletown during enlargement of Eastern Division.
†Abandoned.

Susquehanna Canal Company

The Susquehanna and Tidewater Canal, more properly the Tidewater Canal, was built by the Susquehanna Canal Company, a Pennsylvania corporation, formed under Special Acts of April 15, 1835, and June 21, 1839, and the Tide Water Canal Company, a Maryland corporation, and was located along the west bank of the Susquehanna River from Wrightsville, opposite Columbia, to Harve de Grace, on Chesapeake Bay, in Maryland, a distance of 45 miles. The former company absorbed the latter by stock purchase in 1845, so that the Susquehanna Canal Company was the real owner and operating corporation. The canal was 50 feet wide at the top and 5 feet deep, had

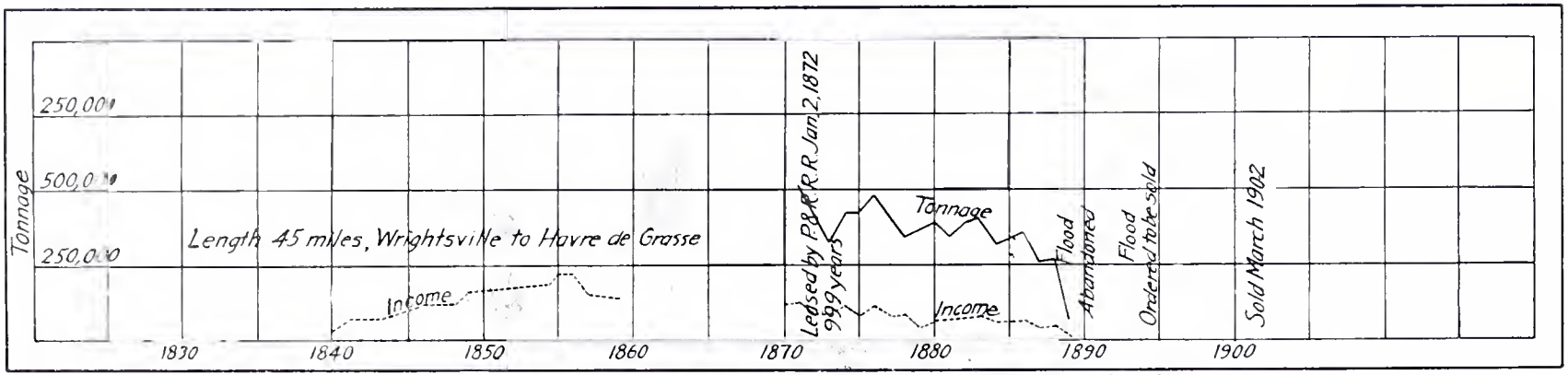


Showing Tonnage and Tolls, Union Canal



Entrance to Tidewater Canal, on Susquehanna River, at Wrightsville, 1886

Entrance to Abandoned Tidewater Canal at Wrightsville, August 1914.



Showing Tonnage and Income, Susquehanna and Tidewater Canal

29 lift and 2 guard locks capable of admitting two boats 85 feet long, the total lift being 233 feet. This line, designed as an extension of the Pennsylvania Canal to tidewater, was a rival to the Union Canal between the Susquehanna River and Philadelphia and was operated by the owners until 1872, the maximum tonnage, which was in 1864, amounting to 528,000 tons.

The canal, which cost nearly $5,000,000, was repeatedly damaged by floods. On January 2, 1872, it was leased to the Philadelphia & Reading Railway Company for 999 years, at $20,000 per year, it is asserted, in reprisal for the lease of the Delaware & Raritan Canal by the Pennsylvania Railroad, June 30, 1871. Injuries by the flood of 1889 were repaired but the canal was more severely damaged by the flood of 1894, and since 1895 has been out of operation. Its abandonment was a serious loss to the Pennsylvania Canal Company which had been dependent upon it for water communication with tidewater just as the Philadelphia & Reading Railway had been dependent on the Delaware & Raritan for its coal delivery to eastern markets. The Philadelphia & Reading Railway Company failed to repair the line after the 1894 flood and abandoned it to the owners, the Susquehanna Canal Company. In 1902 the property fell into the hands of the Susquehanna Canal & Power Company, and through this company the McCall Ferry Power Company obtained rights to construct dams at any point on the property. The capitalization of the company in 1890 was $2,000,746, with a bond issue of $2,901,311 and a floating debt of $52,412.

TABLE No. 13. *Statement of Operations of Susquehanna Canal*

Date.	Tons of Freight.	Receipts.	Expenditures.	Net Earned.
1840,	.....	$41,558	.....	.....
1845,	.....	99,683	.....	.....
1850,	.....	156,965	.....	.....
1855,	.....	211,141	.....	.....
1860,	.....	.....	.....	.....
1865,	325,029	380,160	$237,297	$142,863
1870,	483,235	134,138	.....	.....
1875,	430,846	95,839	84,896	10,944
1880,	382,295	53,630	35,693	17,937
1885,	341,376	57,501	44,182	13,318
1890,	32,948	8,686	18,295	*9,609
1895,	11,021	2,957	3,626	*669

*Deficiency.

Erie Canal Company

The Erie Canal Company, incorporated March 7, 1843, purchased from the State on September 14, 1843, the line from New Castle over the divide to Erie, and the French Creek feeder, and completed the unfinished portion thereof. On January 1, 1845, this company purchased the Beaver Division from the mouth of the Beaver River to New Castle. These lines were operated by the Erie Canal Company until abandoned and sold at sheriff's sale on November 29, 1870. In some places the bed of this canal can still be traced, but much of

it is occupied by railroad tracks, while in Erie buildings have been erected on the right of way.

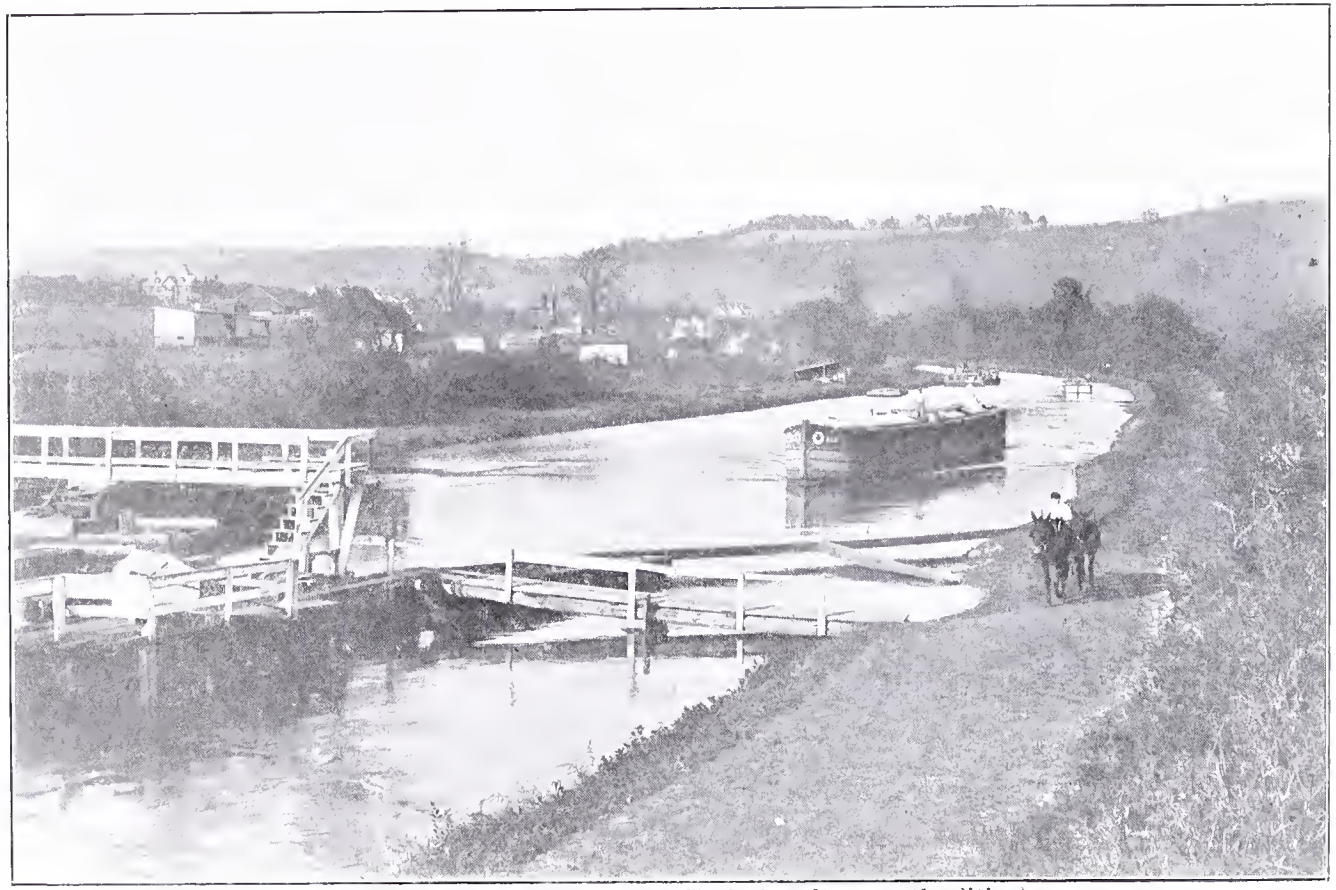
Lehigh Coal & Navigation Company

The Lehigh Coal & Navigation Company, incorporated May 1, 1821, by the merging of the Lehigh Coal Company and the Lehigh Navigation Company, built a canal and improved the river channel from Easton up the Lehigh River to Mauch Chunk, a distance of 47 miles, and slackwatered the river up to White Haven, 25 miles beyond, later also leasing the Delaware Division Canal.

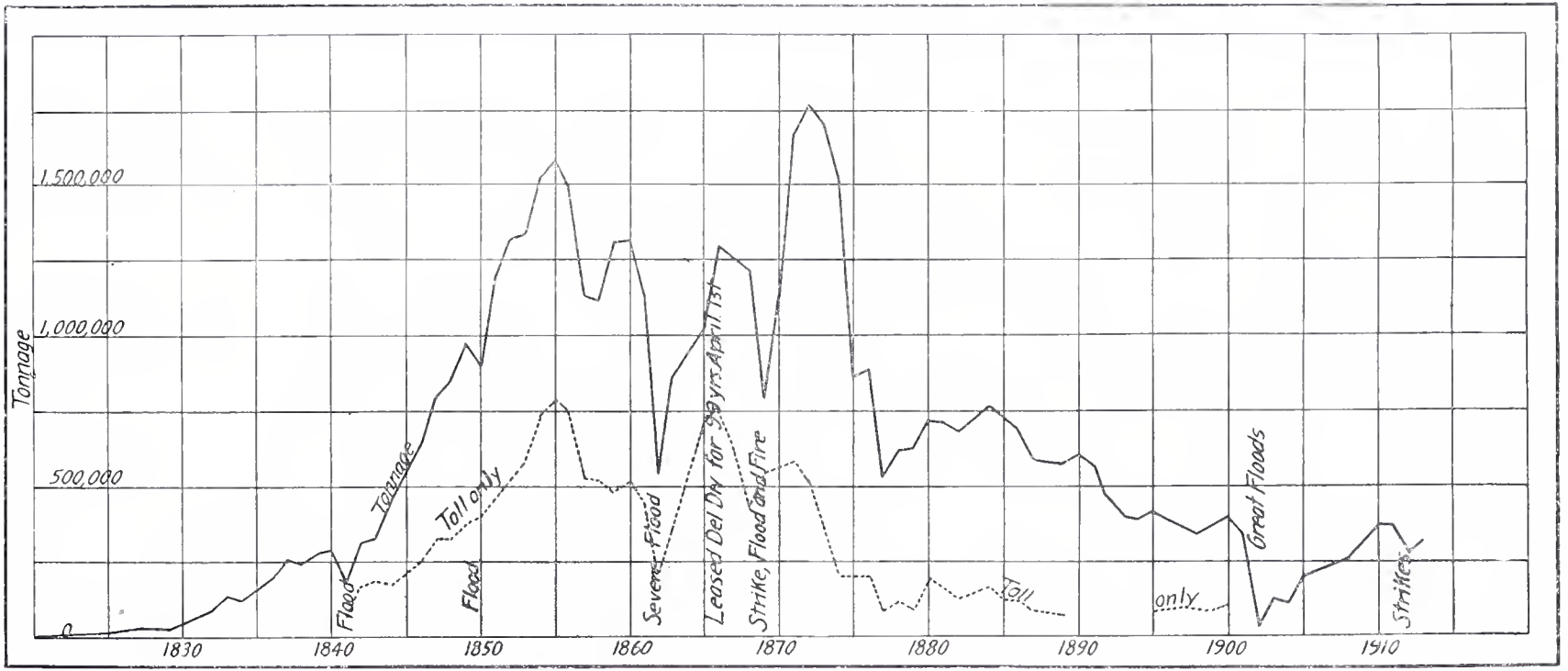
The formation of this company was the outgrowth of a number of attempts to bring anthracite to the Philadelphia market, and its line was strictly an anthracite carrying canal, having been built for this purpose and being largely dependent thereon, as the owners of the company were also owners of large areas of coal land in the vicinity of Mauch Chunk. The first works, a series of wing dams in the river and the removal of bars and riffles, were put in service in 1821, but a drought of unusual intensity proved that there was insufficient water to maintain this form of navigation, and storage reservoirs were built above Mauch Chunk, which when filled were allowed to discharge down the channel and carry the accumulated boats along. The boats used were chiefly rectangular shaped arks of 40 tons capacity, 16 to 18 feet wide, and 20 to 25 feet long, six or seven of them being joined together. These boats were made in the vicinity of the mines and at the end of the journey were sold as lumber, and the navigators walked back to the mines. It was not long, however, before the company decided to canalize and slackwater the river, and in June 1829, a canal, 60 feet wide and 5 feet deep, locks 100 feet by 22 feet, to carry boats of 120 tons capacity, was put in service from Easton to Mauch Chunk. In 1837 navigation was extended to White Haven, 25 miles above Mauch Chunk, this section being only one-half of the size of that below.

In 1826, 31,080 tons, and in 1831, 40,966 tons of coal were moved over the lines, and in 1839 the estimated cost of carrying freight, including tolls, was 1.6 cents per ton per mile. With the completion of the Delaware Division Canal in 1832, between Easton and Bristol, and the Morris Canal between Easton and Newark, N. J., the Lehigh Coal & Navigation Company began using permanent boats for through traffic, these carrying supplies and machinery on the return trips. The company owned its own boats and coal mines, and its traffic to a large extent was self-originated. Dividends were paid quite regularly, that of 1865 amounting to 10 per cent in addition to which $567,837 was added to the surplus.

In 1841 and 1862 floods stopped traffic and caused heavy losses, that of June 4, 1862, caused by a rain lasting 30 hours, resulting in a loss to the company of $1,000,000 and in the abandonment of the



Lehigh Canal and Lock above Treichler (Present Condition)



Showing Tonnage and Tolls, Lehigh Canal

line above Mauch Chunk. A flood in 1869 did further damage and caused the company to devote itself more to its railroads, which it had early commenced to build, and which were eventually to practically replace the canals.

In 1865 the Lehigh Coal & Navigation Company leased for a term of 999 years from the Delaware Division Canal Company its line from Easton to Bristol, guaranteeing 6 per cent on the bonds and 4 per cent on $1,633,350 of stock, and has since operated this line in connection with its Lehigh River Canal. In 1902 the canals of this company were valued at $2,225,300 and the deficit from their operation was $77,037, owing largely to flood damage. The total receipts were $167,698.44, and the expense of operation and maintenance was $248,545.29, giving a deficit of $80,846.85.

In 1909 the company experimented with electric haulage of canal boats, and the results thereof may lead to an increase in the traffic which was unimportant compared with its railroad traffic, amounting in the year ending June 30, 1909, to 328,990 tons. The company owned 148 of the 171 boats operating on the line, which includes 34.76 miles of canal and 12.36 miles of improved river channel along the Lehigh, and 60 miles of canal along the Delaware. The total lift on the Lehigh is 382 feet, overcome by 58 locks, which are 100x22 feet. Present width is 60 to 100 feet at top, and 45 feet at bottom, with a depth of 6 feet. The canal is usually open eight months in the year. At the present time the Lehigh Canal is a considerable source of water power, the fall from the canal to the river being utilized by varied manufacturing concerns which lease the water from the Lehigh Coal & Navigation Company.

TABLE No. 14. *Statement of the Operations of the Lehigh Canal*

Year.	Tonnage.	Receipts from tolls only.	Expenditure for operation and maintenance.	Profits of the Lehigh and Delaware Canals.
1820,	*10,205 bu. coal	.....	.....	.....
1825,	795,000 bu. coal	.....	.....	.....
1830,	50,225	.....	.....	.....
1835,	155,367	.....	.....	.....
1840,	281,802	$143,235 60	.....	.....
1845,	530,346	203,404 91	.....	.....
1850,	884,783	382,504 34	.....	.....
1855,	1,543,646	779,828 20	.....	.....
1860,	1,338,375	522,020 94	.....	.....
1865,	1,047,638	695,289 92	.....	.....
1870,	1,123,490	566,012 11	$182,343 00	$69,440 66
1875,	854,643	†200,000 00	186,744 00	‡88,578 08
1880,	719,338	187,520 00	78,854 00	198,842 48
1885,	689,554	124,507 00	79,316 00	55,071 95
1890,	603,662	.....	.....	.....
1895,	409,684	§87,263 00	§90,239 00	— 2,975 98
1900,	380,579	§98,068 00	.....	10,733 93
1905,	199,766	.....	.....	—49,190 33
1910,	364,972	.....	.....	.....

*Shipped prior to incorporation. †Rented to Central Railroad of New Jersey for $200,000. ‡Delaware Division only. §Includes Delaware Division.

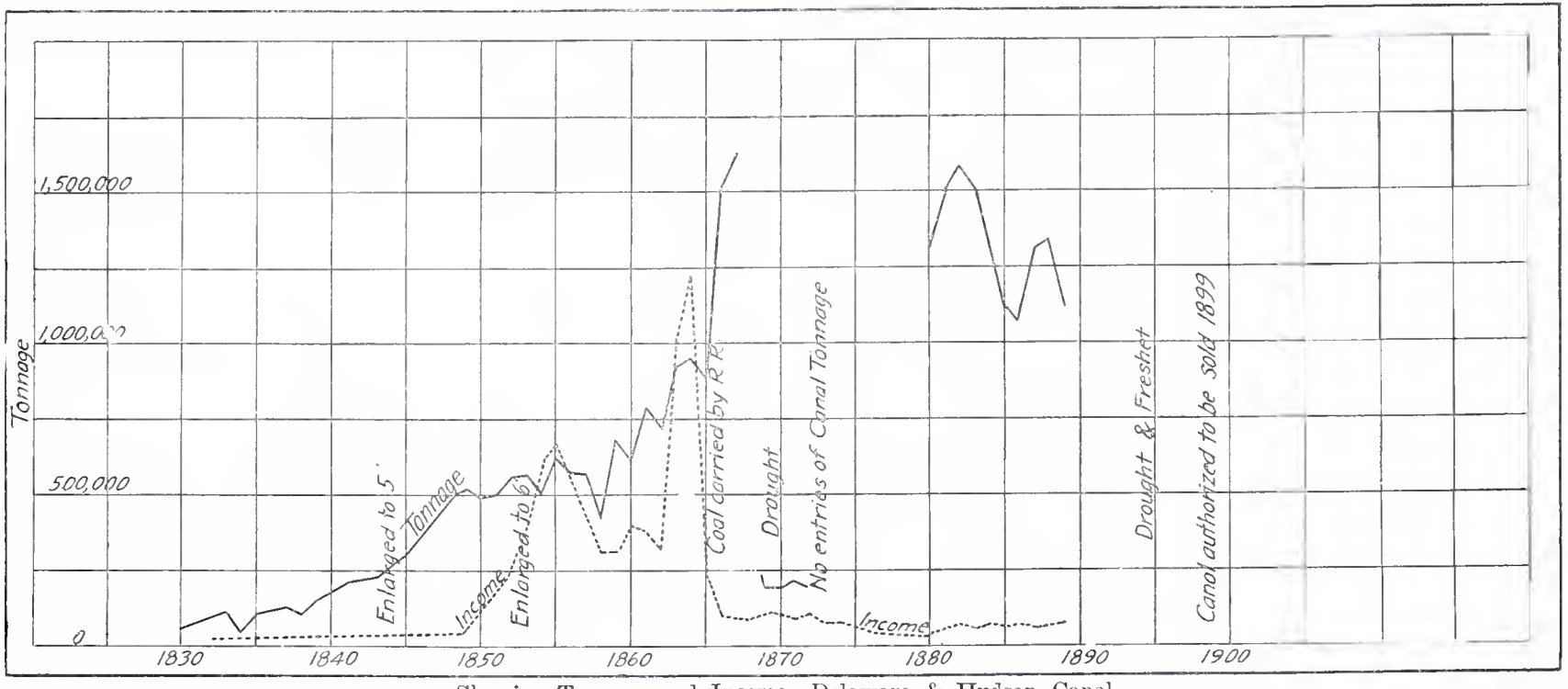
Delaware & Hudson Canal Company

Another canal designed and built in order to carry coal was the Delaware & Hudson Canal, which started at Honesdale, Wayne County, followed the Lackawaxen River 25 miles to its mouth in the Delaware, thence across that river and down the New York side to Port Jervis, opposite Matamoras, Pike County, Pennsylvania, and thence up the Neversink Valley into Rondout Creek and down the said creek to meet the Hudson River at Rondout, N. Y. This line was built by the Delaware & Hudson Canal Company, incorporated by the State of New York, April 7, 1823, to build a canal from tidewater to the Delaware River and up the Delaware to the mouth of the Lackawaxen River. On March 13, 1823, the Pennsylvania Legislature gave this corporation the right to improve navigation on the Lackawaxen River by securing a good descending navigation at least once in every six days for boats of 10 tons, but no toll was to be collected unless the improvement was converted into complete slackwater. The toll was set at 12½ cents a ton passing any lock. Canal building enthusiasm was at this time widespread and the $1,500,000 of this stock was sold in a single day in New York. Like the Lehigh Coal & Navigation Company, the Delaware & Hudson Canal Company owned coal mines at the head of its line, and its main object was the marketing of this coal in New York.

Work was begun on July 13, 1825, progressed with rapidity, and was completed in October 1828, and the first boatload of coal passed through in February 1829. The company prospered, handling some freight other than its own coal, operating as many as 880 boats at one time, and in 1844 the canal was deepened to 5 feet, in 1853 to 6 feet, and the average load per boat became 140 tons instead of 40.9 tons. With these improvements the traffic became large and the cost of transportation of coal from the mines to New York fell from $1.03 per ton to less than 90 cents per ton.

The Pennsylvania Legislature had reserved the right to purchase the canal down the Lackawaxen River at the end of 30 years, and in 1851 a committee from the Legislature examined it with this in view, reporting that $1,246,437.64 would have to be paid for it, the company claiming a much larger remuneration. The State dropped its claim, however, and on April 30, 1852, gave the company a perpetual franchise.

From 1840 to 1867 the company was especially prosperous, particularly during the Civil War period, the annual dividends varying from 7 per cent to 34 per cent, but the company had begun the construction of railroads during this interval and the canal traffic gradually decreased. The greatest tolls received on the canal, $1,213,570.46, was in 1864, but with the diversion of the traffic of the Pennsylvania Coal



Showing Tonnage and Income, Delaware & Hudson Canal

Company from the canal to the Erie Railroad, tolls decreased the next year to $201,679.38. This was all toll on traffic by other companies than the Delaware & Hudson Company itself, and was not the entire income of the company. The drought of 1870 practically shut down the canal, and by 1880 with its increased railroad and coal mine interests the canal had become merely of incidental importance to its owner, as after 1872 the company reports do not show the canal traffic, while in 1889 it ceased operating. The drought and freshet of 1895 damaged the line to an unprecedented extent, and in 1897, $1,264,689 was charged off the company's books to profit and loss, representing the present value of the canal, locks, boats, etc. The abandoning of the line was found to be a distinct advantage to the company.

TABLE No. 15. *Traffic on Delaware & Hudson Canal*

Year.	Total traffic, exclusive of lumber trade.	Tolls.
1830,	43,000	$16,422
1835,	105,087	41,976
1840,	173,663	35,450
1845,	300,272	25,880
1850,	496,671	97,999
1855,	635,296	652,362
1860,	594,778	397,677
1865,	873,244	201,679
1870,	199,972	95,101
1875,	.....	58,309
1880,	.....	42,810
1885,	.....	54,551
1890,	.....	58,183
1895,	.....	42,335

Codorus Navigation Company

The Codorus Navigation Company was incorporated by Special Act, April 12, 1825, and later provided 11 miles of improved navigation on Codorus Creek, extending from York to its mouth in the Susquehanna River, 3 miles being canal and 8 miles slackwater, necessitating 9 locks. This canal was used to transport agricultural and manufactured products from York to connect with the Susquehanna and Tidewater Canal and the Pennsylvania Canal. On this waterway was transported the iron steamboat "Codorus," the first to be built in the United States. This canal was abandoned in 1849.

Conestoga Navigation Company—Lancaster & Susquehanna Slackwater Navigation Company

The Conestoga Navigation Company, incorporated March 3, 1825, constructed and operated slackwater navigation on Conestoga Creek from Lancaster to its mouth in the Susquehanna River, a distance of

18 miles, involving 9 locks and dams, each lock being 100 feet by 22 feet; total descent 62 feet. This line was built to connect Lancaster and its surrounding rich agricultural community with the Susquehanna and Tidewater Canal, Pennsylvania Canal, and Union Canal. This company was sold at sheriff's sale June 1, 1833, reorganized under the name of the Lancaster & Susquehanna Slackwater Navigation Company, which company operated until 1860, when the line was abandoned. Much of the property now belongs to the Lancaster Light, Heat & Power Company, which company operates a series of dams and power houses for the generation of hydroelectric power.

Norwegian Creek Navigation Company

The Norwegian Creek Navigation Company, incorporated April 14, 1827, built a line down Norwegian Creek from Callowhill Street, Pottsville, to the Schuylkill Canal and operated it until abandoned in 1850.

Bald Eagle & Spring Creek Navigation Company

The Bald Eagle & Spring Creek Navigation Company, incorporated April 14, 1834, built a canal up Bald Eagle Creek from the state dam at the head of the Bald Eagle side cut near its mouth, opposite Lock Haven, where it connected with the West Branch Canal to Milesburg, Center County, and thence up Spring Creek to Bellefonte, a total distance of 25 miles. This line was operated until destroyed by the flood of 1889. This canal was built by a private company, but $200,000 of its 5 per cent bonds were guaranteed by the State, which also purchased $25,000 of stock.

Muncy Canal Company

A short line, three-quarters of a mile long, was built at Muncy, Lycoming County, to connect this town with the West Branch Canal, by the Muncy Canal Company, incorporated April 1, 1836. It was abandoned after the flood of 1889.

Junction Canal Company

The Junction Canal Company, incorporated by the State of New York and empowered to do business in Pennsylvania by the Act of April 6, 1852, built two miles of canal and operated same in Bradford County to connect the New York canals with the North Branch Canal. This line was abandoned in 1870.

Monongahela Navigation Company

In the west a company formed for the improvement of navigation was incorporated March 24, 1817, under the name of the President and Managers of the Monongahela Navigation Company, and on March 31, 1836, was given new powers and the name changed to the Monongahela Navigation Company. This company began with capital stock of $48,000 and a plan to build 16 dams to form slackwater navigation on the river from Pittsburgh to the Virginia line, and further if Virginia would give permission. Works were begun in 1837 and by 1844 the river had been slackwatered from Pittsburgh up to Brownsville, 55½ miles, and later to Morgantown, W. Va., 102 miles from Pittsburgh. The company was most prosperous; the capital stock was increased gradually to $1,632,000 in 1890, the State having subscribed to $125,000 worth, in which year it paid a 9 per cent dividend. In 1897 the United States Government acquired the works for $3,761,615.46, and it is now maintained as a free waterway. The dams and locks are being improved, and the system affords cheap transportation for vast quantities of coal from the mines of the Monongahela Valley. The line now extends from Pittsburgh to a point 4 miles above Fairmont, W. Va., a distance of 131 miles. Fifteen locks and dams are in operation, overcoming 155 feet of elevation.

Two connections were constructed by private companies between the Pennsylvania system and the extensive and contemporaneous canal lines of Ohio, namely, the Mahoning and the Sandy and Beaver canals.

Pennsylvania-Ohio Canal Company

The Pennsylvania-Ohio Canal Company (Mahoning Canal) started from the Beaver Division of the Pennsylvania Canals, at the mouth of Mahoning River, and ascending that stream 8 miles crossed into Ohio, and thence continued up the Mahoning River and over the divide to meet and follow down Cuyahoga Creek to join the Ohio Canal at Akron. This line was 85 miles long and cost $764,372, having been built between 1836 and 1840 by the Pennsylvania-Ohio Canal Company, incorporated by the State of Ohio in 1827. It was abandoned and sold in 1877.

Sandy and Beaver Canal Company

The Sandy and Beaver Canal, built by the Sandy and Beaver Canal Company, incorporated January 11, 1828, started at the mouth of Little Beaver River, about 30 miles below Pittsburgh, thence up that stream and over the divide to the Sandy Branch of Tuscarawas River to meet the Ohio Canal at Bolivar. Its length was 73 miles

and it cost $1,500,000. Before the line was completed, however, the company failed and with the exception of 6 miles near Bolivar, which was taken over by the State of Ohio, it was abandoned.

Youghiogheny Navigation Company

Navigation on the lower portion of the Youghiogheny River from McKeesport to West Newton, 18.8 miles, was at one time improved by the Youghiogheny Navigation Company, but today no indications of these works remain. This company was incorporated in 1843, under the name of the Youghiogheny Slackwater Company, and built two dams and locks, each having 13-foot lifts and forming slackwater navigation from McKeesport to West Newton. These works were completed in 1848 and were operated until 1865. The dams were injured by flood in 1861 and the company was at that time insolvent. In 1865 members of the company repaired the dams at private expense, only to have them seriously injured by floods in that year, and in April 1868 the General Assembly passed an act by which the members of the company, who in 1865 repaired the dams, were to be reimbursed pro rata by the sale of the materials in the dams and locks. It provided, furthermore, that these dams must be removed so as not to obstruct navigation. This stream has not been navigable since.

In April 1873 a special act was passed by the General Assembly incorporating the Youghiogheny River Navigation Company, with a capital stock of $500,000, "for the purpose of making a lock navigation on the Youghiogheny River so far as same may be practicable, and to connect the same by a canal with the Chesapeake and Ohio Canal at the Maryland State line." This company was to begin construction within two years after date of charter and complete the same within four years thereafter, but the work was never put under construction. When the Chesapeake and Ohio Canal was first surveyed in 1822, it was contemplated to extend this line over the mountains and down the Youghiogheny River to Pittsburgh, but this canal was never completed beyond Cumberland, Md., 180 miles beyond its terminus at Washington, D. C.

Lake Erie and Ohio River Ship Canal

The present project for a modern waterway connecting Lake Erie with the Ohio River at Pittsburgh originated in a report of the Commission of the Legislature of Pennsylvania appointed in 1889. An engineering committee organized by the Pittsburgh Chamber of Commerce submitted another favorable report in 1895. The Lake Erie and Ohio River Ship Canal Company was organized under charter obtained in May 1905 from the states of Pennsylvania and Ohio, and

holds a national charter by Act of Congress June 30, 1906. This company proposes the construction of a ship canal 13 feet deep, 131.25 feet wide at bottom and 177 feet wide at water surface, with locks 350 feet by 48 feet, to extend from Pittsburgh along the north bank of the Ohio River to Rochester; thence to follow the Beaver River partly by canal and partly by slackwater navigation to the mouth of the Mahoning River; thence up this stream by canal and river to the mouth of Mosquito Creek, where the route turns to the north, following this creek and over the divide at its head into a proposed lake, and on down to Lake Erie at Ashtabula, O. The total length of the line would be 103 miles, 50 miles formed by canalization of Beaver and Mahoning rivers. The number of locks would be 25, each 400 feet by 56 feet, with a total lift from Rochester to the summit of 192 feet, and from thence down to Lake Erie of 287 feet. The locks were designed to pass ships of 2,000 tons capacity. The estimated cost of the completed work was approximately $50,000,000, and five years would be required to complete it. "When completed it will permit lake vessels to carry iron ore direct from the Lake Superior mines to the furnaces along the route of the canal, and for coal to be shipped from western Pennsylvania mines to upper lake ports by an all water route. It has been estimated that the annual traffic through the canal will not be less than 18,000,000 tons, and that there will be a great saving on iron, coal and coke, the commodities which will constitute the greater part of the tonnage through the canal. The whaleback steamers of the type now in use on the Great Lakes will be able to pass through the canal to Pittsburgh."*

It is the intention to procure most of the water for the summit level by means of a diversion canal from French Creek. A dam and reservoir are to be built on that stream near the site of the present Bemis Dam, near Meadville, Crawford County, Pennsylvania, from which water will be drawn (from November 1st to May 1st) to fill a great artificial lake into which it is the intention to convert Pymatuning Swamp, Crawford County, Pennsylvania. This lake as proposed would cover 23.6 square miles and have a capacity of 8,624,992,000 cubic feet. By adding two smaller reservoirs the total storage for the summit level supply would amount approximately to 9,000,000,000 cubic feet. The water will be led from the Pymatuning Reservoir by a tunnel and feeder to Mill Creek, and thence into the summit level.

A route between Pittsburgh and Lake Erie was surveyed by a Commission appointed by the State of Pennsylvania in 1889, and in 1893 the subject was taken up by the Chamber of Commerce of Pittsburgh, and $40,000 was subscribed for additional surveys, which led to the formation of the above company.

*U. S. Census Report—Transportation by Water—1906, page 217.

The Legislature of 1913 passed an act organizing the Lake Erie and Ohio River Canal Board, which is authorized to survey this route, estimate the cost and construct the waterway, assessing the cost upon the counties and states traversed, the same to be paid by bond issues. This survey is now in progress.

PRESENT STATUS OF CORPORATE CANALS

Of the private undertakings, the Lehigh, including the Delaware Division, and Schuylkill canals and the Monongahela Improved Navigation are still in existence and operation. The two former are used almost solely for the shipment of anthracite, but the tonnage handled by this means is not so great as formerly, and the indications are that unless improvements are made these two lines of canal will probably continue to handle a continually decreasing percentage of the coal transported from this region. The Monongahela line, much improved over its early condition, is owned and successfully operated by the United States Government, its main tonnage being bituminous coal.

Table No. 16 shows the principal features of the corporate canal lines:

TABLE No. 16. *Canals and Improved Navigation Constructed by Incorporated Companies*

Name and Location.	Chartered.	Opened for traffic.	Total length in miles.	Canal miles.	Slackwater miles.	Dams.	Locks.	Lift in feet.	Depth.
Delaware & Hudson Canal, Lackawaxen River, Honesdale to mouth.	1823	1829	25	25	0	.....	.....	.....	4 ft. original depth increased to 6 ft..
Lehigh Canal, Lehigh River, Mauch Chunk to Easton and White Haven to Mauch Chunk, ...	1798	1829	47.12 25	34.76 0	12.36 25	8	58	382 600	Originally 5 ft. Present 6 ft., ...
Schuylkill Canal, Schuylkill River, Mill Creek to Philadelphia.	1815	1825	108	58	50	.....	Original 71, Present 55.	618	Originally 4 ft. Present 6 to 6.5 ft., ..
Union Canal & Feeder, Reading to Middletown, ..	1811	1827	99	99	0	.....	95	519.5	Originally 4 ft., ...
Susquehanna & Tidewater Canal, Wrightsville to Havre de Grace.	1845	1840	45	45	0	1	31	233	5 ft., ...
Conestoga Improved Navigation, Lancaster to mouth of Conestoga Creek.	1806	About 1830	18	0	18	9	9	62	.....
Codorus Improved Navigation, York to mouth of Codorus Creek.	1825	About 1830	11	3	8	.....	9	.....	.....
Bald Eagle & Spring Creek Navigation Co., Bellefonte to Lock Haven.	1834	About 1835	25	.....	.....	.....	.....	.....	.....
Monongahela Navigation. Monongahela River, ...	1817	1844	92.3	0	102	15	15	155	.....
Youghiogheuy Navigation, West Newton to McKeesport.	1843	1848	18.8	0	18.8	2	2	26	.....
Norwegian Creek Navigation, in Pottsville.	1827	About 1828	.....	.....	.....	.....	.....	.....	.....
Muncy Canal, at Muncy, ...	1836	About 1837	0.75	.....	.....	.....	.....	.....	.....
Junction Canal, near Athens, Bradford County, ...	1852	About 1853	2	2	0	.....	.....	.....	.....
Pennsylvania-Ohio Canal, along Mahoning River from mouth to state line.	1827	1840	8	.....	.....	.....	.....	.....	.....
			524.97						

TABLE No. 16. *Canals and Improved Navigation Constructed by Incorporated Companies—Continued*

Name and Location.	Width top in feet.	Present Condition.	Remarks.
Delaware & Hudson Canal, Lackawaxen River, .. Honesdale to mouth.	.....	Abandoned in 1899, ...	Original capacity 30-ton boats, increased to 140 tons.
Lehigh Canal. Lehigh River, Mauch Chunk to Easton and White Haven to Mauch Chunk, ...	60 to 100, ... 30, ...	In operation, Mauch Chunk to Easton, by S. C. & N. Co., ...	120-ton boats. Abandoned White Haven to Mauch Chunk.
Schuylkill Canal, Schuylkill River, Mill Creek to Philadelphia.	Originally 36. Present 70,	In operation under lease of P. & R. R. line. Owned by S. C. & N. Co., July 12, 1870,	Originally 55-ton boats. Present 180-ton boats.
Union Canal & Feeder, Reading to Middletown, ..	Originally 36, ...	Abandoned 1885, ...	Originally 25-ton boats. Later 80-ton boats.
Susquehanna & Tidewater Canal, Wrightsville to Havre de Grace.	50, ...	Abandoned 1895, ...	Leased to P. & R. R. R., January 2, 1872. Now controlled by McCall Ferry Power Co.
Conestoga Improved Navigation, Lancaster to mouth of Conestoga Creek.	.....	Abandoned 1860, ...	Operated and built by Conestoga Navigation Co.
Codorus Improved Navigation, York to mouth of Codorus Creek.	.....	Abandoned 1849, ...	Operated by Codorus Navigation Co.
Bald Eagle & Spring Creek Navigation Co., Bellefonte to Lock Haven.	.....	Abandoned 1889, ...	Operated by Bald Eagle & Spring Creek Navigation Co.
Monongahela Navigation. Monongahela River, ...	.....	Now operated by U. S. Government, Pittsburg to W. Va., ...	Built and operated until sold to Federal Government in 1897, by Monongahela Navigation Co.
Youghiogheny Navigation, West Newton to McKeesport.	.....	Abandoned 1865, ...	Built by Youghiogheny Navigation Co.
Norwegian Creek Navigation, in Pottsville, ...	.....	Abandoned 1850, ...	Built by Norwegian Creek Navigation Co.
Muncy Canal, at Muncy, ...	.....	Abandoned 1889, ...	To connect Muncy with West Branch Canal.
Junction Canal, near Athens, Bradford County, ...	.....	Abandoned 1870, ...	Built to connect North Branch Extension with New York Lines.
Pennsylvania-Ohio Canal, along Mahoning River from mouth to state line.	.....	Abandoned 1877, ...	Abandoned and sold in 1877.

CHAPTER V

UNITED STATES GOVERNMENT IMPROVEMENT OF PENNSYLVANIA RIVERS

The Federal Government has improved several of the interstate rivers of Pennsylvania, in which instances obstructions have been removed, encroachments prevented, shoals have been dredged, the water confined by jetties or bulkheads, and on some rivers dams and locks for slackwater have been constructed. By these means the Government has assumed a tacit jurisdiction over the Ohio and Monongahela and over portions of the Allegheny, Delaware and Schuylkill rivers.

This work is done under the constitutional provision by which Government jurisdiction extends over navigable streams. Aside from the Delaware River ship channel from Philadelphia to the sea, the principal Government work has been on the Monongahela and Ohio rivers.

No construction work of a permanent nature has been done on the Susquehanna River in Pennsylvania. The exercise of regulation and supervision over streams by the United States seems to be far reaching in that it is necessary only that a stream be navigable for a limited period, over a small part of its course, for a relatively insignificant class of traffic, to place it within the jurisdiction of the Federal Government. Quite recently, June 1914, the Judge Advocate General of the War Department rendered an opinion that the Susquehanna River, being navigable in both Pennsylvania and Maryland, is an interstate navigable river and hence comes directly under the control of Congress. A previous (1904) decision of the Secretary of War had declared the Susquehanna River in Pennsylvania not to be navigable.

All of the great rivers of the state, the Delaware, Susquehanna, and North and West branches thereof, Monongahela, Allegheny and Ohio, have been classed as navigable streams and upon all of them the Federal Government has expended money for their improvement, the works of the Federal Government on Pennsylvania streams being summarized as follows:

The Delaware River has been dredged and otherwise improved up to the head of tidewater at Trenton.

The Susquehanna has been improved to Havre de Grace, Md., by dredging a channel 12 feet deep.

The Ohio River has been slackwatered throughout its 29 miles in Pennsylvania by dams and locks.

The Monongahela River has been slackwatered throughout its 93 miles in Pennsylvania by dams and locks. The system built by the Monongahela Navigation Company was purchased by the United States Government in 1897 and practically rebuilt.

The Allegheny River has been slackwatered for 24 miles by 3 dams and locks.

Delaware River above Philadelphia

From the Delaware Breakwater at Cape Henlopen at the mouth of Delaware Bay to Trenton is 134 miles, within which distance the United States Government, through the War Department, has confined its attention in the matter of navigation improvement. Above Trenton, which is the head of tidewater, the river is rocky and shoal at most seasons, and is spanned by many low bridges. Estimates have been made of the cost of certain improvements on the upper river but no work, except a few small local measures, has been accomplished.

The tidal portion of the Delaware River has become, by reason of its long use, the numerous large cities along it, its considerable depth up to Philadelphia, and its important function in the Atlantic Intracoastal Waterway plan, one of the most important rivers of the Atlantic seaboard. For this reason the Federal Government has expended large sums in improving its navigability and maintaining a channel up to Philadelphia in keeping with the constantly increasing draft of large craft.

The channel in that portion between Philadelphia and Trenton was, however, in its original condition narrow and tortuous, of varying depth and width, and was available for commercial purposes by steamers and other craft of shallow draft only. Prior to 1910 no comprehensive project had been adopted for the improvement of this part of the river, but work had been done at various times since 1872 at different localities with a view of obtaining a depth of 7 feet at mean low water and a width of 200 feet. Under the general project for improving Philadelphia harbor, a channel 26 feet deep was dredged through Fivemile Bar between 1888 and 1898. The amount expended in the improvement of the Delaware River between Philadelphia and Trenton prior to the adoption of the existing project and exclusive of the sum expended in the improvement of that part of Philadelphia Harbor north of Allegheny Avenue was $197,623.25. The existing project for the improvement of this section of the river was adopted June 25, 1910, and provides for a channel 200 feet wide and 12 feet deep at mean low water, at an estimated cost of $360,000 and an annual cost of $20,000 for maintenance.

The work embraced in the existing project calls for the removal of a shoal about 4,500 feet long at a point about 9 miles above Allegheny Avenue and opposite Mud Island, continuous dredging from Bordentown to Trenton, N. J., a distance of about 4 miles, and of the construction of a double bulkhead dike at the upper end of Mud Island, and two single bulkhead dikes at the lower end of Duck Island and the upper end of Biles Island, the two latter named dikes being between Bordentown and Trenton. Work under the project was completed on May 9, 1913, except for the dike at the upper end of Mud Island. Contract operations covered the removal of 104,715 cubic yards of material from the shoal opposite Mud Island, the removal of 344,404 cubic yards from the section between Bordentown and Trenton, and the construction of 2,034 linear feet of single bulkhead dike. The dike at the lower end of Duck Island, just above Bordentown, has a length of 5,220 feet, and the dike at the upper end of Biles Island has a length of 1,762 feet. Work of removing the shoal at the lower end of Burlington Island, to permit of vessels continuing upstream after landing at Burlington, N. J., was continued and completed with a Government plant, and resulted in the removal of 26,285 cubic yards of dredged material.

The total quantity of dredged material removed in the completion of the channel was 1,010,265 cubic yards, while the quantity to be removed was originally estimated at 1,100,000 cubic yards. The construction of the dike at the upper end of Mud Island has been deferred on account of protests made by owners of property abutting on the Pennsylvania shore back of Mud Island, who contend that the dike would cause shoaling in the back channel, which is now used mainly for pleasure purposes. Aside from the protests, it is desired to make a study of the dredged channel at this particular locality with a view of ascertaining whether it will maintain itself without the aid of the dike. The total amount expended on the existing project up to the close of the fiscal year was $310,979.21, no part of which was applied to maintenance.

The completion of the channel has enabled seagoing vessels of medium draft to reach the manufacturing plants along the line of the improvement for the purpose of loading and unloading cargoes. It has enabled the regular steamers plying between Philadelphia and Trenton to make faster time and maintain their time schedule.

An examination of the dredged channel, made a few days prior to the close of the fiscal year, shows slight shoaling has taken place just below Trenton, opposite Duck Island, opposite Bordentown, N. J., opposite Kinkora, N. J., and opposite Mud Island. The maximum draft that could be carried on June 30, 1913, over the shoalest part of the locality under improvement was 11.1 feet at mean low

water (opposite Mud Island). The mean range of tide varies from 5.3 feet at Philadelphia to 4.2 feet at Trenton.

The commerce carried during the year amounted to 1,547,787 short tons, and consisted principally of coal, dairy and farm products, sand, gravel, stone, bricks and general merchandise. The value of all commerce carried was $7,676,323. The commerce carried shows a small increase in volume and a slight decrease in value as compared with the previous year. As yet the improvement has not caused any marked change in the nature of the commerce carried, nor has it had any appreciable effect on freight rates.

Philadelphia Harbor

A project for the improvement of Philadelphia Harbor, adopted August 11, 1888, was completed January 10, 1898, the resulting channel having a least depth of 26 feet at mean low water, except at one locality just below Cramp's Shipyard, over which the depth was slightly less than 26 feet, with a width varying from 1,015 to 1,850 feet, extending from a point opposite Morris Street, Philadelphia, to the Pennsylvania Railroad Bridge, a distance of 6.2 miles. In 1906 an allotment of $10,000 was made from the emergency appropriation contained in the River and Harbor Act of March 3, 1905, for re-dredging shoal places within the limits of this improvement. The total amount expended in this improvement, including survey of the locality and the acquisition of land, was $3,945,424.75.

Delaware River, Philadelphia to the Sea

In its original condition the width of the channel of the Delaware varied greatly at different points, and obstructions reduced its depth at mean low water to 17 feet at Mifflin Bar, 18 feet at Schooner Ledge and Cherry Island Flats, and about 20 feet at Bulkhead Bar, Baker Shoal and Duck Creek Flats. It was thus available for ocean going vessels of only medium draft. The section included in this improvement project is about 63 miles in length and extends into Delaware Bay for a distance of about 8 miles. The draft that can be carried from the ocean through Delaware Bay to the mouth of the river is 30 feet at mean low water. Forty feet at mean low water can be carried to the lowest point of the section under improvement.

Prior to 1885 efforts to improve the river were confined to dredging, except at Schooner Ledge where solid rock was removed. The work was done under appropriations for special localities and under special appropriations for the Delaware River below Bridesburg. The first permanent and systematic improvement of this section of the river was commenced in 1885, when a project was adopted for a channel 26 feet deep at mean low water, with a width of 600 feet, from a point about one-fourth mile above Allegheny Avenue, Phila-

delphia, to deep water in Delaware Bay. A second project was adopted March 3, 1899, providing for a channel 30 feet deep at mean low water, with a width of 600 feet, from Christian Street, Philadelphia, to deep water in Delaware Bay. The original work under this project was practically completed at the close of March 1911. The amount expended under all previous projects for improving the river below Philadelphia, from 1836 to the time of taking up the existing project, exclusive of the sum expended in the improvement of Philadelphia Harbor, was $10,176,002.08.

A plan for a channel 35 feet deep was adopted in 1910, but is not yet completed. This channel is to vary from 800 feet to 1,200 feet in width, with five dikes to control the tidal flow. The total estimated cost is $10,920,000, with an annual maintenance cost of $300,000. It involves the dredging of 73,208,000 cubic yards of soft material and the removal of 53,260 cubic yards of ledge rock, the construction of five dikes and the extension and completion of three others. The total amount expended to the end of 1913 on this project is $2,101,743.04. The 35-foot channel now extends from Philadelphia Harbor to near Chester, a distance of about 13 miles.

The total amount appropriated by the Government between 1836 and June 23, 1913, for the Delaware River was $15,239,000, and for Philadelphia Harbor $3,945,424, which with contributions from "incidentals" gives a total expenditure of $19,217,864, exclusive of large contributions from Philadelphia and from the State of Pennsylvania. After nearly four score years this has resulted in a 30-foot depth at mean low water, secured mainly by dredging, which is not self-maintaining. The effects of this enlargement during the past 20 years may be seen from the following table giving the value and tonnage of freights carried on the river, in short tons.

TABLE No. 17. *Value and Tonnage of Freight Carried on Delaware River*

Year.	Short Tons.	Value.
1891,	15,049,653	$299,942,124
1892,	16,020,968	293,366,435
1893,	14,925,662	241,473,332
1894,	20,862,077	367,367,308
1895,	19,596,721	480,346,656
1896,	17,095,206	623,896,493
1897,	20,126,306	627,516,986
1898,	19,623,686	757,900,064
1899,	24,550,659	1,312,079,652
1900,	27,091,112	1,546,786,327
1901,	26,741,611	1,206,827,309
1902,	24,464,393	1,621,239,450
1903,	22,827,926	1,289,965,088
1904,	23,372,036	1,579,060,906
1905,	24,383,571	1,612,847,499
1906,	26,111,047	1,472,540,364
1907,	27,283,529	1,538,385,389
1908,	24,023,895	1,249,175,518
1909,	24,677,671	1,327,869,862
1910,	25,496,213	1,340,391,894
1911,	25,786,180	1,209,879,741
1912,	26,267,335	1,235,106,621

The population of Pennsylvania increased from 5,258,014 in 1890 to 7,665,111 in 1910, being a gain of 2,407,097, or 45.7 per cent in 20 years, or at an average rate of 2.28 per cent per annum. For the entire United States during the same period the rate is 2.42 per cent. From the above exhibit it appears that during the second decade the tonnage has increased very slightly, while the value of the traffic has not even held its own, regardless of the growth of population and industries.

The average tonnage for the five years, 1893 to 1897 inclusive, is about 18.5 million; that for the next five year period is 24.4; that for the next 24.6; and for the last, 1908-1912, it is 25.2, while the actual freight movement of 1912 is 823,777 tons less than that of 1900 and its value is reduced by $311,679,706, leading to the conclusion that so far as the channel works are concerned they have not been able to neutralize the negative influences which have apparently retarded the normal development of the State's commerce.

Relative Position of the Port of Philadelphia

As the commerce of a port is largely dependent upon its accessibility and terminal charges, it is worthy of note from the foregoing data that even as late as 1911, when the 30-foot project was officially reported as completed, the ruling depth was 25.9 feet on the Cherry Island Bar and the tonnage for that year was 25,786,180 short tons, having a value of $1,209,879,741, as compared with 27,091,112 tons in 1900, valued at $1,546,786,327, being a decrease in tonnage of 1,304,932 tons and $336,906,586 in value, notwithstanding the liberal appropriations from the national and state treasuries and the shifting of many millions of cubic yards of silt in the bed of the river. Whether it be a sequence or not of this policy of improvement, the fact remains that this port has fallen to the fifth place in the extent of its foreign commerce* as given by the report of the Commission of Commerce and Navigation for 1913, as follows: (1) New York, $2,000,000,000; (2) Galveston, $290,000,000; (3) New Orleans, $252,000,000; (4) Boston, $216,000,000; (5) Philadelphia, $170,000,000; (6) Baltimore, $150,000,000, and (7) San Francisco, $130,000,000, etc.

The following exhibit of the arrivals and clearances at the port is furnished by the courtesy of the Commission of Navigation, indicating the fluctuations of its water borne traffic during the past 14 years, showing an increase of about 25 per cent during that period, or less than 2 per cent per annum, so that it has not even kept pace with the growth of population.

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*Value of imports and exports, the latter being six times the former.

TABLE No. 18. *Net Tonnages (Foreign and Domestic) for the Port of Philadelphia, 1900 to 1913*

Year.	Arrivals.	Clearances.	Totals.
1900,	6,091,201	5,909,375	12,000,576
1901,	5,859,106	5,830,164	11,689,270
1902,	5,409,779	5,447,468	10,857,247
1903,	5,955,648	6,249,618	12,205,266
1904,	5,464,142	5,434,237	10,898,379
1905,	6,165,713	6,261,754	12,427,467
1906,	6,401,189	6,370,985	12,772,174
1908,	6,808,334	6,510,106	13,318,440
1909,	7,134,012	7,385,930	14,519,942
1910,	7,215,479	7,048,561	14,264,040
1911,	7,459,691	7,567,982	15,027,673
1912,	7,171,942	7,160,517	14,332,459
1913,	7,517,503	7,611,444	15,128,947
Average,	.....	.....	13,033,990

The State and the City of Philadelphia have co-operated with the Government in certain of these works and Philadelphia has prosecuted other work through its Bureau of Surveys. In 1905 the State and City together appropriated $750,000 to be expended on the 30-foot channel under the supervision of the United States.

Schuylkill River

Previous to 1902, Philadelphia constructed a channel 500 feet wide and 26 feet deep through Tinicum shoals in the Delaware River, but since that date has confined its attention to the improvement of the Schuylkill River, which has frequently been dredged by the City and the spoil deposited on shore. Numerous bridges span the river, all up to Walnut Street having draw spans. The channel is designed to be not less than 26 feet by 250 feet up to the Atlantic Refining Company's docks, and the City has expended about $1,000,000 on this improvement.

Prior to 1899 the Philadelphia Bureau of Surveys constructed a channel in the Schuylkill River, 250 feet wide and 22 feet deep, from Penrose Ferry Bridge to Fifty-eighth Street and 150 feet wide and 20 feet deep, from there to a point about 500 feet above Harrison's Wharf, at a cost of $220,000. In 1901 Philadelphia appropriated $250,000 and in 1902 $400,000, which was spent in constructing a channel 26 feet deep and 250 feet wide from Penrose Ferry Bridge to a point about 200 feet below Passayunk Bridge and 20 feet deep by 200 feet wide for about 0.4 mile beyond. With the completion of this work a 26-foot channel will extend from the mouth of the Schuylkill River almost up to Passayunk Bridge.

In 1913 the Pennsylvania Legislature appropriated $250,000 for work on the Delaware River, to be expended by the United States. The employment of an engineer was also authorized to represent the State in the matter of the expenditure of these funds.

The regulation of shipping on the Delaware River is in the hands of a state board, authorized by Act of Assembly June 8, 1907, P. L. 496, known as the Board of Commissioners of Navigation on the River Delaware and its Navigable Tributaries.

The Philadelphia Department of Wharves, Docks and Ferries regulates these matters within the limits of the Philadelphia Harbor district.

Susquehanna River

The navigability of the Susquehanna River, which flows through New York, Pennsylvania and Maryland, draining 46.4 per cent of the area of this Commonwealth, has received little attention from the Federal Government. For a time its rapids and obstructions were circumvented by canals on its banks, all of which are now abandoned, while near the Maryland State line the river is crossed by a high masonry dam without locks, and at several points elsewhere by low permanent masonry arch bridges, as well as many steel structures. The dam above mentioned was built, however, only after its owners agreed to install a lock, if required.

Practically all of the attention of the Federal authorities has been devoted to the Susquehanna River below the Pennsylvania-Maryland State line and below the head of tidewater.

An estimate, made some years ago, placed the cost of creating slackwater by means of 26 dams and locks, between Pittston and Athens on the North Branch, a distance of 92 miles, at $4,605,000, but nothing was done thereon.

In 1880 a report was made upon improvements near Wilkes-Barre and some jetties and wing dams were built for the purpose of improving purely local conditions. An Act of Congress dated March 3, 1879, directed a survey of the river to be made, and on June 14, 1880, an appropriation of $15,000 was made for improving the channel from Richard's Island (a few miles below Wilkes-Barre) up to the Pennsylvania-New York State line. The survey was made by Col. James Worrall, formerly an engineer on the state works, under the direction of Col. J. N. Macomb, U. S. Engineer, to whom he reported December 2, 1879, as follows:

"During the survey the water was lower than for 60 years, giving exceptional opportunities to examine the bed, yet there were 190 miles of canals then in operation between Havre de Grace and Wilkes-Barre, carrying coal at less than half a cent per ton mile. Above

the Nanticoke Dam the rise is only about 2 feet per mile and the valley is broad and flat. The ponds are separated by riffles, none of which exceed two feet and the entire distance to be improved does not exceed 12½ miles out of the 177 to the state line. The cost for this two-foot navigation is estimated at $250,000 for the entire distance, but this very shallow depth is very far indeed from what may be effected through these magnificent valleys." In this report three trunk line routes were recommended as follows:

(1) From Pittsburgh via the Allegheny, Kiskiminitas and Conemaugh (with a 5-mile tunnel through the Allegheny Mountain), the Juniata, and the Susquehanna to its mouth.

(2) Up the Allegheny to Red Bank, or parallel stream, the Sinnemahoning, West Branch of the Susquehanna River, and thence to the bay.

(3) From Buffalo via Erie Canal for 150 miles to Montezuma, thence via Seneca Lake and Chemung Canal to Elmira, and down the Chemung Valley and North Branch to Chesapeake Bay.

The dimensions proposed were locks 120x20x7 feet and canal trunk 70 feet wide at bottom, 7 feet deep with slopes of 1 on 2 to convey boats of 280 tons capacity. (For tabular details of river see Report 1880, page 600, et seq.)

The result of the report was a few desultory efforts to remove shoals at various points to a depth of 3 feet and the building of submerged dikes, for which the estimates were $48,537. Between 1881 and 1884 there were dredged some 17,700 cubic yards from the riffles, 927 cubic yards of rock were blasted, and 625 linear feet of dike built, but "no general project was ever adopted. This river has no commercial standing." On the West Branch a survey was ordered by Act of July 5, 1884, which resulted in an unfavorable report from the officer in charge on the ground that "the river is not a navigable river in the ordinary acceptation of the term and the improvement is not a public necessity." "The timber when cut is made up into rafts and floated to a market. In this sense only can this river be considered navigable. No steam or sail craft has ever been seen on the river. In one year three thousand rafts, worth between $4,000,000 and $5,000,000, have come down the river."

At and below Havre de Grace the river is broad but the channel is narrow and divided by Watson's Island. A 12-foot draft can be carried to the docks. The original project, dated February 22, 1853, was estimated to cost $50,000, and improvements carried on by the Government since that date had cost $97,390 up to August 2, 1882.

The present project contemplates a channel 15 feet deep and 200 feet wide and the removal of the shoal opposite Watson's Island to a depth of 8 feet at an estimated cost of $168,000, subsequently in

creased to $200,750 on December 2, 1911. The amount expended to June 30, 1913, was $167,972.01, of which $18,480 was for maintenance. The work is three-fourths completed. The maximum draft in the channel was 12 feet; mean range of tide 2½ feet; length of all improvements about 5½ miles. The commerce is reported to be as follows:

TABLE No. 19. *Commerce on Susquehanna River to Havre de Grace*

Year.	Short Tons.
1905,	151,528
1906,	82,673
1907,	95,437
1908,	37,927
1909,	(not stated.)
1910,	192,675
1911,	352,335
1912,	87,762

Amount expended during fiscal year, $3.89; unexpended balance, $51,257.09; total appropriations, $316,620.

Ohio River

The Federal Government has built six dams and locks in the Ohio River between Pittsburgh and the Pennsylvania-Ohio State Line, securing a minimum navigable depth of 9 feet, as a part of a general project which, when completed in accordance with this standard, will extend to the mouth of the river at Cairo.

Since the main purpose of the state works (1825-34) was to unite the trade of the west with the seaboard, and the mountain barriers, requiring transhipments, delayed traffic and increased cost, the trunk line railroads were completed at an early date to connect the Ohio with the Delaware, and although communication was made by rail across the old Portage Road as early as December 10, 1852, the through line was not completed until February 2, 1854. It was soon discovered that when the stage of the Ohio was too low for navigation the traffic of the railroad was impaired and diverted to other routes, so that the President of the Pennsylvania Railroad Company, Mr. J. Edgar Thompson, in his address of January 15, 1852, said: "This company possesses the shortest and best communication between the Atlantic and Ohio River, and which has been heretofore the only available outlet for the products of nearly one-half of the states of this Union. Should this river be improved so as to secure this object, which it is entirely practicable to accomplish, its preeminence will be maintained and the cities created by its influence will continue to increase and prosper; but if left to the uncertain navigation that now exists, a large part of the trade will find vent over the new railroads now being constructed to the Atlantic. To

none does the importance of this subject present stronger claims than to the citizens of Pittsburgh and Philadelphia and the stockholders of this company," etc. This policy of river improvement was persistently maintained under Mr. Thompson's administration. In 1857 he referred to the intimate relation between the stage of water in the Ohio and the tonnage of the railroad, saying: "The through tonnage in 1856. was 165,162 tons, and the local 288,829, in which was included 190,344 tons of coal. During the first six months when the Ohio was navigable the through exceeded the local trade, but during the last six months there was a greater loss, owing to low water, to compensate for which our western railroad connections afford no adequate relief. With the aid afforded by the cheaper transportation upon the Ohio River, when it is navigable, discriminations against us can be overcome, but when that navigation fails Philadelphia cannot expect to maintain a produce trade of any magnitude," etc. Again—"With the advantages of uninterrupted navigation upon this river very little freight would pass to the seaward from the Ohio Valley via the Lakes. This can only be accomplished by the states (bordering on the river) converting it into a slackwater navigation; to the stock of such a company the Government might become a subscriber as formerly in the Louisville and Portland Canal, a work which has been attended with incalculable advantages to the whole country."

Thus early was the great utility of this remote stream urged upon the attention of the seaboard cities and states; yet as late as 1895, coal fleets containing 1,200,000 tons, having a total valuation of $6,310,000, were detained from April 18th to November 28th awaiting a flood to carry them down stream. Toward the end of the season the cost of keeping them afloat was estimated at $2,000 a day, as both banks were lined for miles by these fleets which were released only shortly before the closure of the river by ice.* This congestion caused a suspension of many industries, entailed an enormous loss of perishable articles, raised prices of transportation, and when finally relieved resulted in wrecks in the river due to collisions of the fleets. So enormous is this traffic down the Ohio that the steamer "Sprague" has conducted a flotilla of 57,500 tons from Louisville to New Orleans in a single trip.

During the past century numerous surveys and projects have been made by corporations, states and the National Government for the improvement of this important waterway, all of which have resulted in the present project of the Government to create a 9-foot stage by the construction of 54 movable dams between Pittsburgh and the mouth at Cairo. The river is navigable at times throughout its entire length of 967 miles between these points and its traffic is augmented by that from numerous tributaries. An enormous tonnage of

*See Franklin Institute Journal, February 1906, "Commerce and Deepwaterways" (with illustrations).

coal comes from the Monongahela River and considerable traffic in iron and steel products originates in the Allegheny River and at Pittsburgh, which freight is carried to Cincinnati, Louisville and points along the Mississippi River to New Orleans.

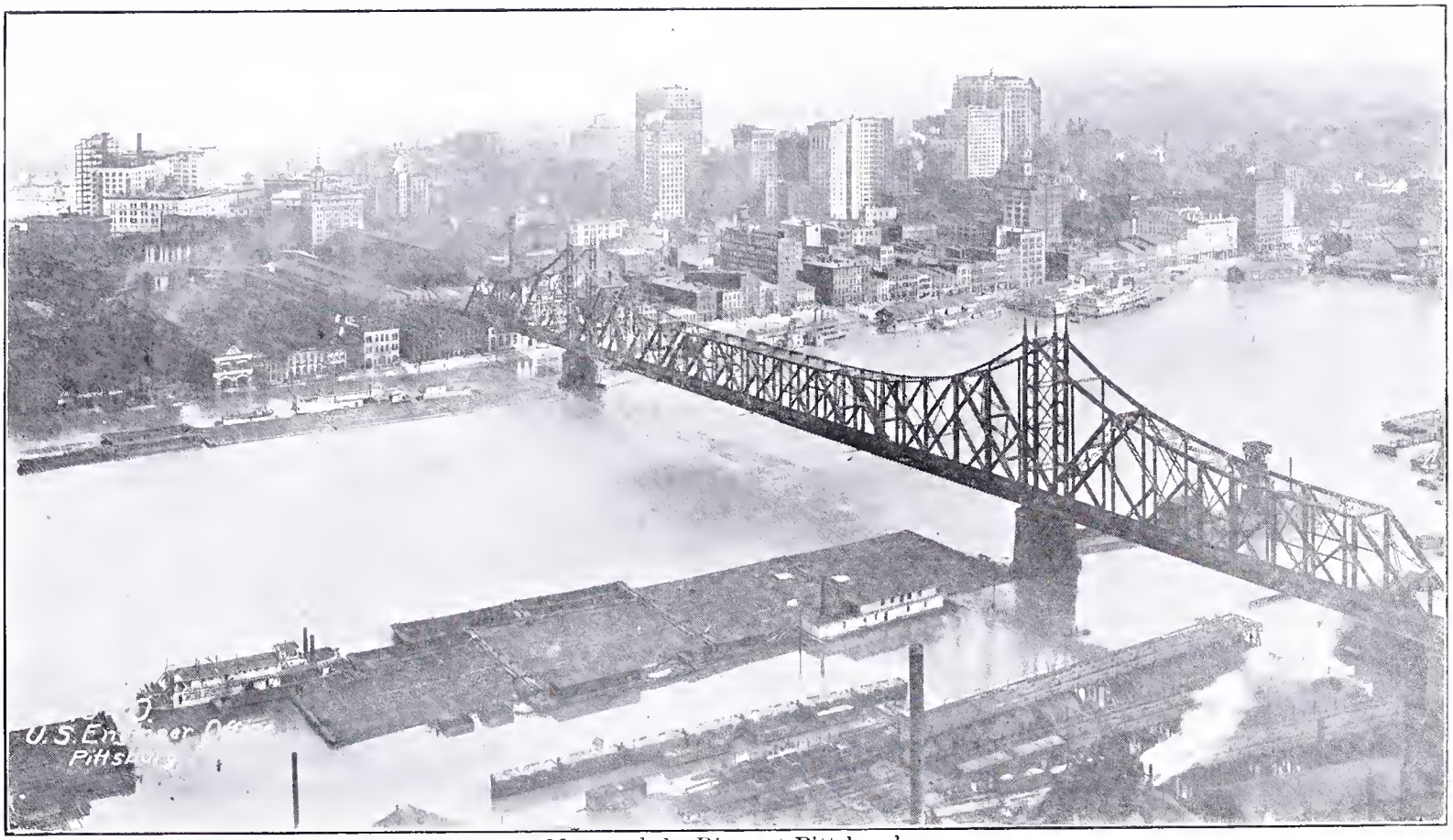
In its original condition the Ohio River in Pennsylvania had a low water channel depth varying from one foot at Pittsburgh to two feet at the Ohio State line, the average slope being 1.25 feet per mile. In 1843 a report on the Ohio River from Pittsburgh to Louisville was submitted to Congress. This report was based on a survey by the U. S. Engineers, summarizing what had been done up to that time toward improving navigation, and enumerating the general method of improvement which had been considered; but it resulted in no definite action. About 1850 an investigation was made of the possibility of improving navigation on the Ohio River by means of storage dams on its tributaries, and it was reported that during the dry season 3 to 5 feet of water could be thus maintained. Reports have also been submitted and rejected by several army engineers upon projects to secure 6-foot depth by canalization.

The first improvement of this stream by the Federal Government was the dredging of a number of shoals in 1827, but it was not until 1875 that a project was adopted for securing 6 feet slackwater depth by means of movable dams and locks. Under an old scheme, Dam No. 1 (Davis Island Dam), 5.5 miles below Pittsburgh, was begun in 1877 and completed in 1885 at a cost of $940,833.31, and a Bear Trap weir was built in 1889 at a cost of $32,857.56. Dams Nos. 2, 3, 4, 5 and 6 have also been constructed in Pennsylvania, under the Act of September 19, 1890, calling for a navigable depth of 9 feet, the locks being 110 x 600 feet. To June 30, 1912, a total of $7,360,340 had been expended on this project. The various dams and locks were put into service on the following dates:

	Completed and put into Operation.
No. 1,	October 7, 1885.
No. 2,	November 12, 1906.
No. 3,	June 25, 1908.
No. 4,	June 30, 1908.
No. 5,	November 21, 1907.
No. 6,	August 17, 1904.
No. 7,	..... 1911.
No. 8,	July 14, 1911.

The completed project now adopted for 9-foot depth from Pittsburgh to Cairo is estimated to cost $63,731,488 in addition to money already expended, and involves 54 new locks and dams and one old

Ohio River, U. S. Government Lock and Dam No. 8



Monongahela River at Pittsburgh

lock and dam. It is estimated that by this improved waterway coal can be shipped from Pittsburgh to Cairo, nearly 1,000 miles, for $0.4335 per ton.

Of the 54 dams in this system the 1913 report of the Chief Engineer U. S. Army stated that seven were authorized but not under contract. Until the entire system is completed and a 9-foot stage created and maintained in the Mississippi River and its tributaries, the full benefit of this great Federal Internal Waterway cannot be realized.

The following table gives the tonnage passing through the Locks on the Ohio River:

TABLE No. 20. *Tonnage on Ohio River*

Year.	Tonnage.
1894,	3,145,803
1895,	2,807,998
1896,	3,811,759
1903,	4,724,938
1904,	3,289,215
1905,	3,083,359
1906,	3,247,753
1907,	4,021,806
1908,	3,060,835
1911 (through Lock No. 1),	4,105,609

Pittsburgh Harbor

Pittsburgh is the most important inland river port in the United States. The traffic on the Allegheny and Monongahela rivers centers there, and from Pittsburgh shipments are made down the Ohio and Mississippi rivers, and a smaller amount is received from down river points. This harbor, which has a total length of 27.2 miles, extending from Davis Island Dam in the Ohio River up the Allegheny 7 miles, and up the Monongahela 15.5 miles, is an important harbor for mooring coal fleets, while they await boating stages in the lower Ohio River. It is also valuable for loading and unloading raw materials and manufactured products to and from Pittsburgh, McKeesport and the many large plants which are located along the three rivers within its limits. The original depths, previous to improvements in the lower harbor, were from 3 to 4 feet, and often very low stages caused complete suspension of traffic. With the completion of Davis Island Dam the maximum draft over the shoalest places in the lower harbor was 8 feet, with portions from 10 to 12 feet and even 16 to 20 feet in depth. The average widths of the harbor at pool-full surfaces are: on the Ohio about 1,000 feet; the Allegheny 930 feet; and the Monongahela 750 to 950 feet. The capacity of the harbor is impaired by shoal places and by high dumps of manufacturing wastes project-

ing from the banks, while low bridges interfere greatly with traffic, especially on the Allegheny, as the boats require a clearance of 44 feet while the bridges vary from 27½ to 35½ feet.

The original project for improvement of the harbor adopted on March 3, 1899, provided for dredging a channel through the lower harbor (below Dam No. 1 on the Allegheny and Monongahela rivers) where needed, 10 feet deep at pool-full and 500 feet wide below Smithfield Street Bridge, Monongahela River, and of less width above the bridge, and in the Allegheny River limited by lines from ends of channel spans of the adjoining bridges. The total cost of construction, maintenance and operation to November 30, 1909, has been $152,390.51. The improvement of the river below the state line is not germane to the purpose of this report and is omitted.

The following table gives commercial statistics for Pittsburgh Harbor:

TABLE No. 21. *Commercial Statistics for Pittsburgh Harbor*

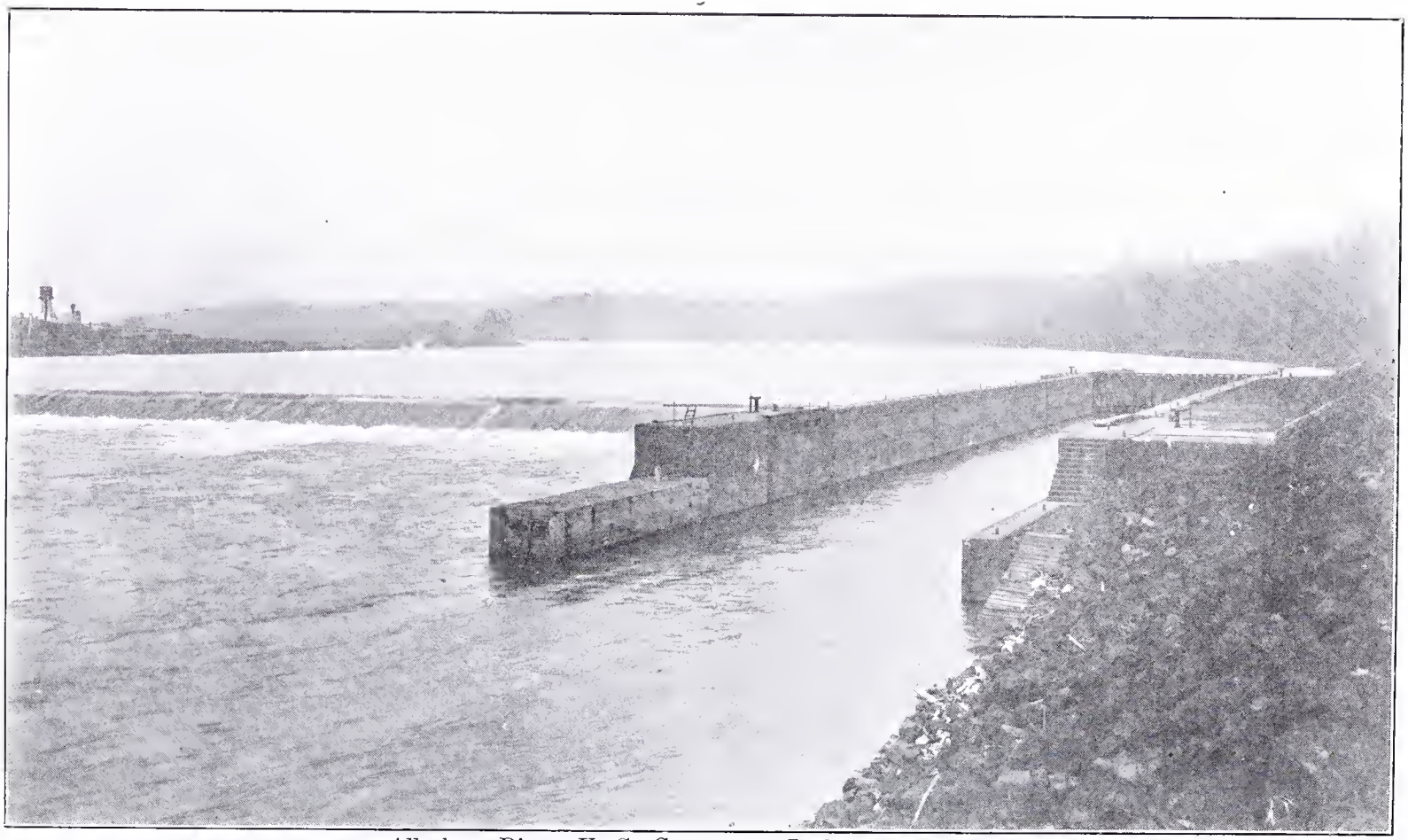
Calendar Year.	Products (Net Tons.)	Passengers.
1900,	8,141,451	884,415
1901,	10,916,489	817,800
1902,	12,252,405	996,500
1903,	12,240,360	702,269
1904,	9,373,448	604,477
1905,	12,269,020	603,716
1906,	12,927,975	271,450
1907,	14,395,816	533,280
1908,	11,454,895	267,043
1909,	12,426,154	699,251
1910,	12,314,664	683,172
1911,	12,519,776	682,807
1912,	12,476,323	796,616

The total expenditures of the Federal Government up to 1908 on the three rivers at Pittsburgh was $19,944,607.62.

Allegheny River

The Federal Government has completed three movable locks and dams across the Allegheny River from Pittsburgh to Natrona, 24 miles, effecting 8-foot depth. The project now adopted contemplates the extension of this system to a point 61 miles above Pittsburgh.

Prior to 1876 the commerce on this river was confined chiefly to lumber and oil, so that the Government reports stated that its improvement was "not justified" and that the lack of clearance under the bridges was a serious menace, as some were barely above flood height. In 1880 a report was presented to show the practicability and advisability of its improvement as a continuation of the Ohio River improvement. A project was adopted involving the improvement of the Allegheny River in 1878 and 1880 by the United States Government for the removal of boulders and snags and the construction of low dams and dikes to close secondary channels and



Allegheny River, U. S. Government Lock and Dam No. 3

concentrate the low water flow on shoals. The work already done on this project enabling navigators to operate safely on stages from two to three feet lower than formerly have been secured at a cost of $266,078.68 (up to June 30, 1911). The principal traffic is the downstream transportation of rafts, coal boats, barges and flats, usually loaded with tan-bark, lumber, posts, railroad ties, gravel, stone, sand, etc. Steamboating is not now conducted to any considerable extent above Tarentum. The annual commerce above slack-water improvements in course of construction is about 400,000 tons, extending over 230 miles from Tarentum, Pa., to Olean, N. Y., in which stretch small sums have been expended by the Federal Government in maintaining a clear channel by removing snags, etc.

Prior to the completion in 1885 of the Davis Island Dam in the Ohio River, it was impossible to navigate the Allegheny River with steam craft of even the lightest draft during the low water periods, which frequently continued for months at a time. This dam afforded an 8-foot navigation two miles up the Allegheny River. The low clearance of many of the existing bridges was another serious obstacle to navigation even with sufficient water.

Dam No. 1, at Herr's Island, is a movable, Chanoine-type dam, with Bear Trap weir, and lock 55x286 feet, and has been in operation since January 1, 1903. Dam No. 2, a fixed concrete dam on a pile foundation, at Aspinwall, 7 miles above the mouth, the lock at this point having been completed and put in operation on November 10, 1906. Dam No. 3, at Springdale, 17 miles above the mouth, a fixed crib dam, has been in operation since September 1904. These dams afford a constant depth of 8 feet. Locks No. 4 and 8 inclusive are to be 56 x 360 feet. The cost of the work, including construction, maintenance and operation to June 30, 1913, has been $2,012,657.33.

The Act of July 12, 1912, providing $300,000 for five additional locks, extending the navigation some 61 miles upstream at an estimated cost of $2,788,000, was rendered inoperative by the condition that the local interests contribute $300,000 and that no part of the appropriation be available until assurance be given that the "channel spans of the bridges forming unreasonable obstructions to navigation" be modified. No such assurances having been given, "no estimate for additional appropriation was submitted." The general results to date are briefly summed up on page 994, Report of Chief of Engineers, U. S. Army, 1913, as follows: "The work that has been done enables navigators to operate safely on stages from 2 to 3 feet lower than formerly."

A project has been submitted involving the extension of slack-water to the New York State line, 209 miles above Pittsburgh, and including 54 dams and locks, at a cost of $13,500,000, but it is un-

derstood that no decision has as yet been reached, although the extension of slackwater to Monterey, 83 miles above Pittsburgh, involving 8 additional dams and locks, is receiving serious consideration, although it does not appear to have been sanctioned as late as June 30, 1912.

The following table shows the tonnage passing through the lower section of the Allegheny River:*

TABLE No. 22. *Tonnage on Lower Section Allegheny River*

Year.	Tonnage.	Passengers.
1892,	953,406	.....
1899,	2,570,900	.....
1900,	1,611,103	.....
1901,	2,420,099	.....
1902,	1,848,321	.....
1903,	2,293,429	.....
1904,	2,155,547	.....
1905,	2,464,445	.....
1906,	2,583,757	.....
1907,	900,202	.....
1908,	536,129	9,636
1909,	1,181,963	25,415
1910,	1,384,626	24,374
1911,	1,815,219	19,345

Monongahela River

The Monongahela River is slackwatered for 7-foot depth from Pittsburgh to a point 4 miles above Fairmont, W. Va., a total distance of 131 miles, of which about 90 miles are in Pennsylvania. This improvement was completed by the Federal Government after purchase of the franchise and works of the Monongahela Navigation Company. The construction of the National Road from Cumberland Gap on the Potomac to Brownsville on the Monongahela River in 1806 led directly to the plan for improvement of the Monongahela. The Monongahela Navigation Company, first incorporated in 1817 and given new powers in 1836 improved the river by a system of dams and locks, at first between Pittsburgh and Dunkard's Creek, 87½ miles, and subsequently to Morgantown, W. Va., their work not being finally completed until 1889. This improvement facilitated the development of rich deposits of bituminous coal, so that the Monongahela tonnage soon exceeded the combined tonnage of all the other rivers of the Ohio basin. The company's project provided a 4-foot channel (with 6-foot part way) by means of 7 dams and 11 locks, the first four being in pairs. These locks were 190 by 50 and 250 by 56 feet, and overcame a fall of 62 feet.

The extent of these improvements in 1886, when efforts were begun to do away with corporate tolls on the river through acquisition of the property by the Federal Government, is shown in the accompanying table.

*Report of Chief of Engineers, U. S. Army.

TABLE No. 23. *Dimensions of Locks*

Lock and Dam No.	Distance above mouth of river—miles.	Length of pool—miles.	Maximum lift—feet.	Inshore Lock.				Outer Lock.				Length of dam—feet.
				Length—feet.	Width—feet.	Depth.		Length—feet.	Width—feet.	Depth.		
						Lower sill—feet.	Head wall—feet.			Lower sill—feet.	Head wall—feet.	
1,	1.30	10.20	10.49	250.0	56	9.0	9.0	190.0	50	7.5	9.0	962.58
2,	12.00	13.10	8.18	250.0	56	6.0	9.0	190.0	50	6.0	9.0	916.00
3,	25.10	16.25	8.89	313.5	56	6.0	9.0	190.0	50	6.0	9.0	687.50
4,	41.35	18.75	11.43	262.2	56	6.0	8.0	190.0	50	5.0	8.0	602.97
5,	60.12	9.20	12.21	196.0	50	4.5	4.5	.....	.....	.....	.....	606.00
6,	69.32	14.50	12.61	190.0	50	5.0	4.5	.....	.....	.....	.....	631.00
7,	83.82	5.00	11.30	190.0	50	6.0	6.0	.....	.....	.....	.....	525.50

Under government supervision the system was extended by additional locks and dams and as a result of condemnation proceedings, covering ten years or more, the company was finally awarded the sum of $3,761,615.46, of which $160,000 was reserved to liquidate outstanding bonds, so that by July 7, 1897, the river became free. In this appraisement the physical value of the works was placed at about $2,000,000, but that of the franchise varied from $3,634,720 to $5,000,000 independently of about $250,000 of bonded indebtedness. It was claimed in the testimony that the market value of the capital stock would not be a just and fair valuation of the property, since it had been affected by the attempts of the United States to obtain possession, while the property was also much more productive than ten years before.

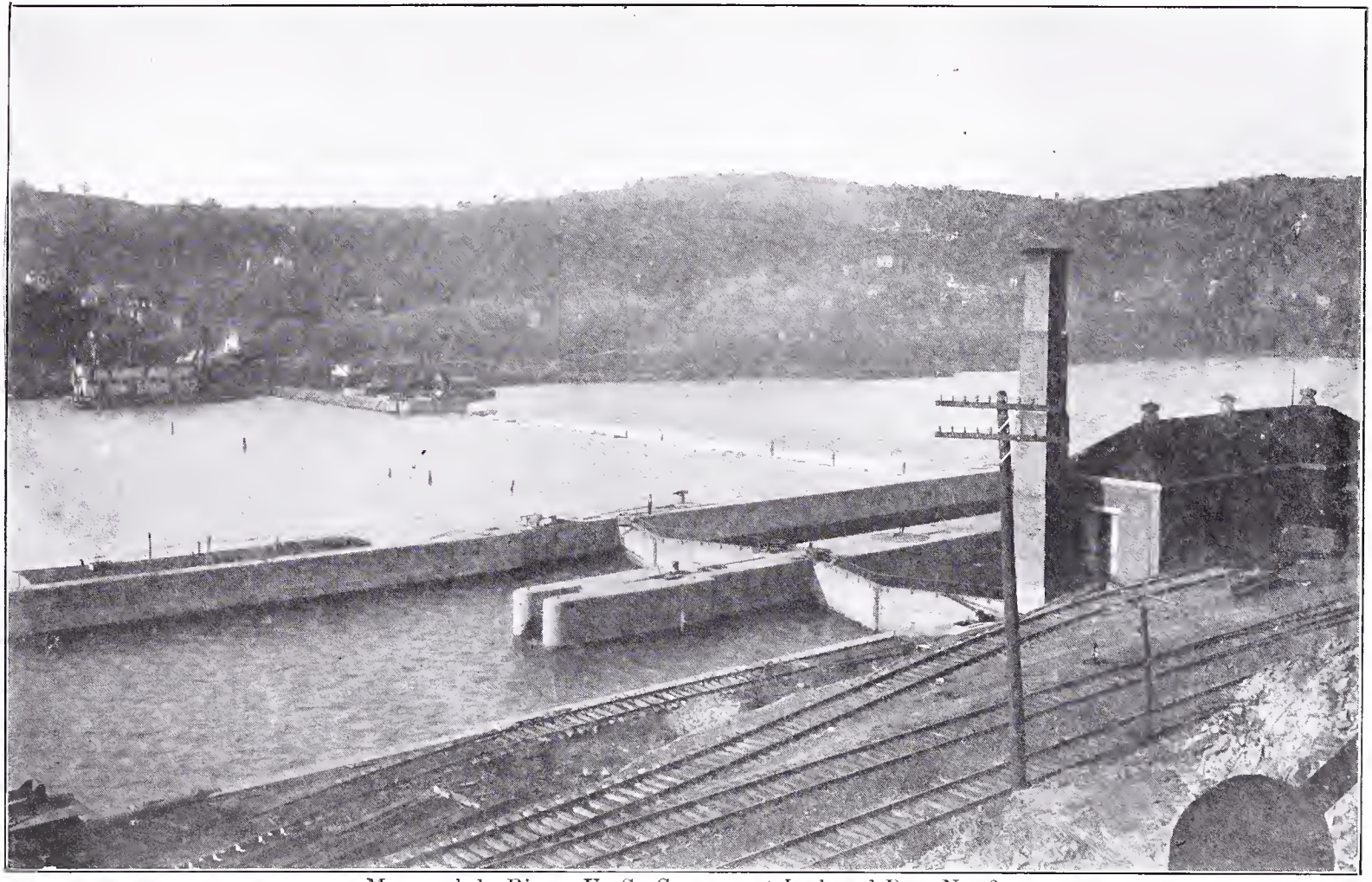
Since acquisition the Government has modified the plans to provide for the enlargement of lock No. 6 and rebuilding of locks Nos. 2, 3 and 5, using in each case two parallel locks each 56x360 feet and fixed concrete dams with movable tops, all at an estimated cost of $2,237,605. On March 4, 1913, dam No. 6 was further modified at a cost of $350,200.

The traffic is still hampered by the inadequacy of lock No. 4, which was being enlarged in 1913, during which year the total tonnage passing the 15 locks in use was 33,048,354 short tons and 150,088 passengers. One large consumer carries coal 50 miles by river at a cost of less than 10 cents a ton as compared with 45 cents by rail, thus effecting a saving of nearly a million dollars annually.

The entire system in Pennsylvania and West Virginia now comprises 15 locks and dams, Nos. 1 to 4 inclusive being double locks. The total expenditure on the Monongahela River by the United States Government up to June 30, 1913, including the purchase of the works, has been $6,188,296.

The effect of improved navigation on freight rates, particularly on coal, is considerable and this effect increases directly with the length of the haul. The freight rate by water on coal in barge loads to a point 12 miles below Pittsburgh was $6\frac{1}{4}$ cents per ton, while by rail to the same point it was 40 cents per ton.

The following table taken from the 1913 Report, Chief of Engineers, U. S. Army, shows the tonnage hauled on the Monongahela River during the years 1902 to 1912 inclusive:



Monongahela River, U. S. Government Lock and Dam No. 3

TABLE No. 24. *Traffic on Monongahela River*

Year.	Tonnage.	Passengers.	
1902,	9,100,887	181,527	
1903,	11,369,814	101,457	
1904,	9,268,736	116,171	
1905,	9,211,752	78,458	Fiscal year.
1906,	11,447,444	77,134	
1907,	11,817,128	47,216	
1908,	12,772,508	42,373	
1908,	9,667,229	28,164	
1909,	11,486,278	47,205	
1910,	10,927,430	47,089	Calendar year.
1911,	10,747,041	33,371	
1912,	11,575,329	38,732	

From this table it appears that the average annual tonnage since the emancipation of tolls under government control is about 10,500,000 tons, and that it is virtually constant while the passenger traffic has shrunken to about one-fifth that of twelve years before.

If the saving in tolls be taken at only 25 cents per ton, then on 12,000,000 tons the annual economy is $3,000,000, which at 3 per cent would represent $100,000,000 as the value of this improvement to the Nation, developed by state and corporate initiative.

The proximity of the extensive deposits of coal with the improved slackwater navigation have created the great industries at the headwaters of the Ohio River, and as a concrete instance of these beneficial agencies it is recorded that one industrial corporation in Pittsburgh and vicinity is using nearly 4,000,000 tons of fuel, of which about 2,500,000 tons are converted into coke at its ovens situated 50 miles below the mines, while the balance is sent down the Ohio River 20 miles to the mills at Aliquippa.

"The actual cost of moving the coal in their own boats, including their return empty, through three locks, and also including salaries, repairs, renewal of plant and interest on capital invested in boats, is not in excess of nine cents per ton, whereas by rail the charge for the same distance would be 37 cents per ton. The total saving on this item must now amount to fully one million dollars annually." The finished products are transported to market by rail.

Thus do the cheaper water facilities encourage manufacturers and contribute directly to the prosperity of the railways. Another large concern is running "quite a fleet of large, steel 1600-ton boats to Louisville when the condition of the Ohio permits," and yet it is known that they have refused to ship cargoes to river points except at the rates fixed by railroads, thus restricting development and destroying natural advantages.

Somewhat similar conditions seem to exist in the eastern parts of the state, for the "Commercial Chronical" of February 28th calls attention to the fact of a railroad from the mines to the seaboard

charging 65 cents per ton mile for merchandise and 83 cents per ton mile for coal, an excess of 18 cents for coal. Another railroad having leased the competing water route increased the rate from 70 cents to $1.70 and carries the coal by rail.

Youghiogheny River

This river, at one time improved to West Newton, by locks and dams by a private corporation and destroyed by floods and abandoned about 1865, has been surveyed and reported upon by U. S. Army Engineers but no construction work has been done. The final report contemplates three dams and locks between the mouth and West Newton, 19.5 miles, at a total cost of approximately $950,000.

The feature that has called attention to this relatively small stream is the enormous coal and coke traffic originating on it. Although favorably reported on by the Board of Engineers for Rivers and Harbors, it was rejected by the Chief of Engineers, who reported that "the locality is not considered worthy of improvement by the Federal Government."

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

The waterways of Pennsylvania have played an important role in the development of the state throughout each of the three epochs. Small boats on the unimproved rivers proved faster and more efficient than overland traffic; later the canals showed vast advantages over the rivers in their natural state and today the extensive improvements of the lower Delaware, Ohio, Monongahela and Allegheny rivers offer facilities far superior to those afforded by the canals.

The rivers which were never canalized or slackwatered like the upper Delaware, Raystown Branch of the Juniata, upper Allegheny, etc., ceased to carry a significant tonnage many years ago, and now, together with those formerly canalized but since abandoned, have practically no part in the great problem of transportation. The three canals which have persisted in their efforts to maintain life exist by reason of charter requirements and the desire to hold other valuable rights conferred, rather than because of their importance in the handling of traffic. To adapt them to the requirements of modern trade would be costly. These three canals are operated by companies which also operate railroads paralleling them and the conditions above described have developed under this control. There is no experience upon which to base an answer to the question as to whether or not the same conditions would exist had the State preserved its interest in the canals.

The Federal Government is actively at work upon our great rivers with the exception of the Susquehanna, and when the authorized projects now under way have been completed Philadelphia and Pittsburgh will be much benefited and Pennsylvania will have great waterways extending well into both her western and eastern borders. The situation with regard to the Susquehanna is quite different, for although it is our largest river and has been examined and surveyed with a view to improvement of navigation, it is still practically in its original condition. For three-quarters of a century it was extensively used, first by small boats in its unimproved condition, and then by partial canalization, but now only occasional stretches above dams are used and these solely for pleasure craft, while a few ferries cross it and a number of flat bottom boats and dredges engaged in coal recovery operations utilize it.

In 1904, by order of the Secretary of War, the Susquehanna River above the Maryland State line was declared not to be a navigable river. For the time being this decision effectively disposed of the possibility of Federal improvement. However, in June 1914 the present Secretary of War revoked the decision of the former secretary and the river is now an interstate navigable stream. This great waterway, although expensive to improve for deep water navigation, taps a tonnage of vast proportions and touches many large and thriving cities in New York and Pennsylvania. For this Commonwealth alone to undertake its improvement would be impossible by reason of the fact that its usefulness would be impaired unless the system of improved navigation extended into Maryland to meet the Federal Channel, and this Pennsylvania could not accomplish. It is thus properly a question to be solved by the Federal Government with such co-operation from the states of Maryland and Pennsylvania and from water power and other corporations as may be worked out to meet the conditions. As the benefit would largely accrue to Pennsylvania, this state should aid in furthering the work by making a thorough study of its advisability and praticability, in order that the matter may be placed in definite form before the War Department.

Under the law of economic evolution the locus of large manufacturing centers is fixed by the cost of transportation of the raw material as well as of the finished product, and these are determined largely by the existence of water routes. It was due to this fact that the commercial supremacy of Philadelphia was lost to New York after the opening of the Erie Canal from the Lakes to the Hudson. The improvement of the Monongahela gave an immense stimulus to the industries of Pittsburgh through the low rates on fuel, and the early construction of the Lake Erie and Ohio River Ship Canal, so zealously urged by some of the citizens of that city to secure the Lake Superior ores, may prove beneficial to the iron and steel plants of this greatest industrial center of the world by the greater economies which would thus be made possible.

Probably in most instances the determining factor in the selection of a manufacturing site is the question of freight rates, which determine the market range of the product. Had the lake divide, between Pittsburgh and Ashtabula, been surmounted by the proposed deep draught canal for barges, even at a cost of $50,000,000, the diversion of trade to the seaboard, following the opening of the line of least resistance across New York, costing over $130,000,000, would have been largely restricted, but the overland carriers appeared to feel confident that they could successfully take care of these raw

materials at rail rates and that the canal, if built, would confiscate their rights instead of benefiting them by relieving them of the more bulky and less profitable traffic.

In the report for 1897 of the Consulting Engineer on the Lake Erie and Ohio River Ship Canal it was estimated that the saving to be effected by this waterway would be 77 cents per ton on ore, and from the lake region 72 cents per ton on coal to lake ports, thus reducing the cost for the former from the present quotation of $2.03 to $1.26 and giving to the Pittsburgh district an advantage of 49 cents a ton on lake ore over New York even with its enlarged canal in operation, but still leaving New York without competition from the other sources of supply. The estimated total tonnage on the canal was 18,500,000, of which about 7,000,000 would be coal from the Monongahela, thus greatly reducing costs of manufacturing on the Lakes and Atlantic seaboard, and 7,000,000 tons would be ore, effecting a like saving in this manufacturing industry.

From the above history of the early canals and improved waterways of Pennsylvania it would appear that in numerous instances, contemporary with their construction or soon thereafter, short lines of railroad were built, usually at the upper end of the waterway, to bring the traffic, which was largely anthracite, to the water. These railroad feeders increased in number and length downstream until finally the canals and waterways were in every case paralleled thereby. As a result of frequent disastrous floods or exceptional droughts, more attention was given to the construction of railroads and less to the operation of the water routes, until finally the former replaced entirely, or nearly so, the latter mode of transportation. In the matter of the anthracite canals, water transportation could not be extended in all cases to the mines and some method of transporting the coal from the operations to the boats was necessary. First, wagon roads were built; then inclined planes; and finally railroads. Had the mine openings been at the water's edge, requiring no auxiliary or feeder lines and no transhipments, the building of railroads by navigation companies and others might have been postponed considerably. It is to be noted that the Wyoming Valley coal fields lie largely in the Susquehanna Valley, the mine openings being adjacent to the water's edge, in many cases permitting the loading of boats directly from the breakers. It was perhaps this condition that enabled the canal along this stream to remain in operation to so recent a date, and this would also be a considerable element in the success of slackwater navigation in the Susquehanna River.

It does not seem to be upheld even by the strongest adherents of the policy of river improvement that internal river navigation will replace rail carriage to any material degree, but the opinion is rather

widely held that heavy bulk freight and long haul freight can be more advantageously and more economically hauled by water, and that these classes of freight would constitute the bulk of the traffic on improved rivers, while the railroads would carry the more costly freight and that destined for shorter hauls. Thus to the railroads would be left the more profitable traffic and they would be relieved of the great outlays of capital necessary to provide increased trackage, rolling stock, terminals, classification yards, etc., to accommodate the enlarged traffic in all grades of freight which is inevitable.

It is held by some that waterway improvement and new canals should and will be built for specific purposes, to handle a specific traffic and designed only therefor. Thus the Lake Erie and Ohio River Ship Canal is proposed almost exclusively to handle the iron ore from the Lakes to Pittsburgh, and soft coal on the return.

Perhaps the strongest argument against the improvement of navigation on the rivers of the country has been that the watercourses do not penetrate to the actual source of much of the freight which they should handle, nor do they extend to the destination thereof. Thus one and often two transhipments are necessary, and such transhipments are costly and the reduction in cost effected by water carriage must be enough cheaper than rail carriage to compensate therefor. The same boats adapted to traffic on improved rivers would not be suitable for service on the coast or for international trade, and transhipments would be required at the river mouth for distant points; and furthermore, boats adapted to one river might not be adapted to the conditions existing on another and transhipment would be necessary. Just as the many different gages of track among the railroads, existing at one period of railroad construction, made transhipment necessary between railroads and resulted finally in the almost universal use of the standard gage track, so the improvement of our streams must comply with a standard so that boats may be used as generally as possible on different waterways.

The completion of the Intracoastal Waterway System, hereinafter referred to, will remove a part of the foregoing objection in that it will permit river craft to reach all of the large cities along our Atlantic coast, thus necessitating only one transhipment, namely, that at the headwaters of navigation. In some cases even this would be eliminated, as adequate water transportation would ultimately lead to the establishment of industries along the banks of these streams for the purpose of securing the advantages due to direct transportation and an adequate industrial water supply, the latter being no small factor in determining the location of many large manufacturing establishments. The methods which are in use on the Ohio River for handling the coal barges, by assembling them in large fleets to be

handled by a powerful tug or steamboat, could also be applied equally well to the handling of river traffic upon the Intracoastal Waterway, and especially upon the Chesapeake and Delaware bays.

The values of ship canals, waterways of sufficient depth and width to carry ocean and lake going vessels, is one at present receiving wide attention. The success of the Suez Canal, connecting the Mediterranean Sea with the Red Sea; the Sault Saint Marie Canal, connecting Lakes Superior and Huron; the Welland Canal, connecting Lakes Erie and Ontario; the Panama Canal, and the renewed activity of New York State in widening and deepening the Erie Canal, have directed interest to this subject. The great claim for canal transportation has always been cheapness of freight charges, and the deep and wide ship canals reduce the cost of transportation by smaller canals because of the lack of necessity for transferring freight from canal boats to steamships at the terminals.

The Lake Erie and Ohio River Ship Canal project involves the most feasible location for a ship canal to the Great Lakes, and other deep waterways may be necessary to develop the state. The eastern rivers offer opportunities and the traffic offers inducements for the construction of improved navigation on these streams, and with the demand for additional and cheaper transportation facilities the time has arrived when these routes should be thoroughly investigated. The railroads are becoming overtaxed, their rates are high, and the waterways would relieve the former and assist in reducing the latter.

Such works need not necessarily be undertaken by the State; experience has shown that private or corporate undertakings of this nature were more successful in Pennsylvania, but they should be under the supervision and control of federal or state authority, in order that the best results may be obtained; and it might be that through the investigations of the State, facts may be disclosed which will lead to the consummation of such projects.

In closing its report to the Governor of the Commonwealth, relative to the status of incorporated canal companies, the State Railroad Commission of Pennsylvania stated as follows:

"The possibilities of canal transportation in competition with modern railroad facilities have never been tested in this state, and the Delaware River, extending along our entire eastern border, and with its tributaries draining a large and important section of our state; the Schuylkill River and the Susquehanna River with their tributaries, making practically all the remaining industrial centers east of the Allegheny Mountains, including the anthracite coal fields, and all three of these important waterways reaching tidewater, seem to invite the development of slackwater navigation."

An added commercial importance is given the eastern rivers of Pennsylvania by the fact that they will act as feeders to the Intracoastal Waterway System now partly under construction by the Federal Government and which will ultimately afford a protected passage for modern barge navigation between New England and Florida. The completion of a free trunk line of this kind will provide for the first time the conditions needed for profitable development of interstate water transportation on modern lines. The Atlantic seaboard is drained by 148 navigable rivers, most of which will be inter-connected by this Intracoastal Waterway, giving a total tributary mileage of 5,365 miles. Through the reconstructed barge canal this system will be connected with the Great Lakes, with Lake Champlain, and the St. Lawrence River. The improvement of the Delaware, the Lehigh, the Schuylkill, the Susquehanna and its branches thus takes on far more than a local aspect, and the cordial co-operation between the Government and the State toward this end is highly desirable.

James J. Hill, of the Northern Pacific Railroad, said in an address in 1907: "Today the entire country is suffering from a want of transportation facilities to move its business without unreasonable delay. The prevailing idea with the public is that the railways are short of cars, while the facts are that the shortage is in tracks and terminals to provide a greater opportunity for the moving of cars." He suggests a remedy in the construction of canals and waterways. The people of the State of New York have consented to the expenditure of $130,000,000 for extending the Erie Canal; and the enlargement of the Delaware and Chesapeake Canal is contemplated at an expenditure of $8,000,000. The subject seems to be worthy of thorough inquiry by the State of Pennsylvania.

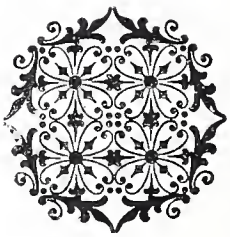
Recommendations:

1. Canal companies were formerly created by special acts, and while laws relating to corporations have since 1874 greatly multiplied, none have been provided for the incorporation of canal and water transportation companies, except the Act of June 24, 1895, and the supplements of June 8, 1907, providing for the construction of ship canals between the Great Lakes and points on the navigable rivers of this Commonwealth and thus having a limited application. The Commission believes that the General Assembly might well consider this important subject and enact a system of general laws regulating the incorporation of canal and water transportation companies, providing for the construction and operation of canals and waterways, the said system to be of such a broad and liberal char-

acter as to afford encouragement to those inclined to invest capital in such works, and to meet the requirements of modern commerce and transportation. Such laws should be so guarded as to prevent the possibility of such companies passing under the control of competitive or rival interests.

The Commission recommends that provision be made for a survey and necessary estimates for the canalization or slackwater improvement of the important rivers of the state, and to determine the practicability of employing the dams, which may be necessary for navigation, as a means of generating power.

The problem of river improvement in Pennsylvania, as may be seen, is highly complex. On either side of its mountain divide the rivers of the state are connected with navigable interstate waterways in course of extensive improvement by the Federal Government. The utilization of these facilities to the benefit of the State of Pennsylvania requires a certain degree of co-operation by the State, while any improvement of the rivers of Pennsylvania on their upper courses adds to the problem of navigation those of hydraulic and hydroelectric power, forest and stream conservation and flood prevention. To this end, federal, state and corporate interests must be allied according to a general plan, which can best be determined through a general survey to be authorized by the State, and in which all these various problems may be considered and worked out in detail.



Commonwealth of Pennsylvania

WATER SUPPLY COMMISSION OF PENNSYLVANIA

Water Resources Inventory Report

PART X

CULM IN THE STREAMS OF THE ANTHRACITE REGION

ACT OF JULY 25, 1913

HARRISBURG, PA.
WM. STANLEY RAY, STATE PRINTER
1916

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(Appointed December 1, 1915, vice Benjamin K. Focht, Resigned)

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LETTER OF TRANSMITTAL

Office of the Water Supply Commission,
Harrisburg, September 20, 1916.

His Excellency, the Governor of the Commonwealth of Pennsylvania:

The Members of the Senate and the House of Representatives of the Commonwealth of Pennsylvania:

Gentlemen:

The Water Supply Commission of Pennsylvania respectfully submits herewith Part X of the Water Resources Inventory Report, entitled "Culm in the Streams of the Anthracite Region."

THE WATER SUPPLY COMMISSION OF PENNSYLVANIA,

THOMAS J. LYNCH,
Secretary.

PART X

CULM IN THE STREAMS OF THE ANTHRACITE REGION

(The data herein contained were collected during the year 1914, and the conditions described were those then existing.)

CHAPTER I

INTRODUCTION

Eighty-five million tons of coal are prepared annually in the anthracite region of Pennsylvania. Of this amount, from twenty-five to thirty-five million tons are produced by what is known as the "wet process," a process that has resulted in the most serious contamination of the streams that run through or have their source in that region. In the production of twenty-five to thirty-five million tons of coal, about forty billion gallons of water carrying ten million tons of fine culm are discharged into the watercourses direct, flushed into the mines, or disposed of by various means on the surface. The extent to which the very small sizes of anthracite have been deposited in the rivers draining the coal fields is made evident by the fact that over a quarter of a million tons, designated generally as river coal or culm, are recovered annually from the river beds by coal washing operations.

The contamination of the streams in the coal region has been in progress for more than fifty years, and it is estimated that there are now six-hundred and sixty miles of creeks and small streams which should be available for water supply but which are rendered useless for domestic and manufacturing purposes by the culm and sulphur water from the mines. The Lackawanna River from Forest City to its mouth; the North Branch of the Susquehanna from Pittston to Sunbury; the Susquehanna from Sunbury to Chesapeake Bay; the Lehigh River from a few miles below White Haven to the mouth, and the Schuylkill River from its source to the Delaware River carry this waste from the anthracite region, an aggregate distance of four hundred miles, subjecting thousands of acres of rich, alluvial flats within the flood zones to serious damage by the deposition of culm, while every year this detrital matter is extending further down stream. The effect of the coal deposition is shown by stretches of formerly rich farm land now abandoned to weeds and brush where such will grow. In some instances the lands are the property of the

coal companies, and in a few cases where they are not so owned damages have been paid to the owners. In the Hazleton, Schuylkill and other regions, many creeks have been so loaded with culm that they have spread over the entire valley bottoms, killing standing timber and all other vegetation. The beds of the rivers are clogged with mine waste deposited in eddies, behind bridge piers and below islands, and pools above dams have become so filled with this material that their efficiency is impaired.

The presence of mine waste in watercourses is due to two causes, both within the control of the mining companies:

First. The deposition of culm and mine waste on low ground where it is subject to overflow and is washed into the streams by the swift current of spring floods. This has been such a common practice along the Lackawanna River for probably fifty years that the stream bed is filled with mine refuse to a depth of from two to six feet, and a bar has formed at its mouth that extends over three hundred feet into the Susquehanna River for a half mile down stream.

Second. The discharge into the streams of culm bearing water from the coal washing operations, from which much damage resulted during earlier years when most of the slush passed into the nearest watercourses; a practice generally followed until the value of much of the material previously thrown away was discovered.

This mine waste, when properly handled and placed, is of value to the mining industry in extinguishing mine fires, arresting "squeezes" and protecting the surface from "caves," thus increasing the ultimate yield. Some companies are either flushing this waste material into mines or storing it on the surface for future use, but the streams are still receiving a quantity sufficient to render them useless for water supply, to impair their value for manufacturing purposes, and to fill up their channels so that overflow is frequent.

Along the smaller streams, where the current is rapid, the water is black and the culm is carried in suspension and deposited in the larger creeks and rivers; but where the flow is sluggish, culm settles quickly and is carried to the main watercourses only during freshets. For this reason, streams that at low water are almost clear may carry a large quantity of culm in times of high water and do more local damage to surrounding territory than those which regularly discharge their burden into the rivers. Frequently during floods the great deposits that have accumulated at the mouths of tributaries are washed down stream.

It is probable that the Lackawanna River will not be fit for use for the next fifty years, the Susquehanna from Pittston to Shickshinny for one hundred years, and the Schuylkill for one hundred and fifty years.

Realizing the tremendous waste of our natural resources by this pollution of the watercourses, the damage to farm land and the other consequences of overflow, by material which, if properly used, would increase the ultimate yield of the anthracite fields, the Legislature passed an act, approved the 27th day of June, 1913, "To preserve the purity of the waters of the State, for the protection of the public health and property," which provides:

> "Section 1. Be it enacted, &c., That, from and after the passage of this act, it shall be unlawful for any person, partnership, or corporation to place or discharge, or permit to be placed or discharged, in or into any of the running streams of this State, any anthracite coal, anthracite culm, or refuse from anthracite coal mine; or to deposit any such coal, or culm, or refuse upon the banks of such stream, where the same would be likely to slide into or be washed into such stream. Provided, however, That this act shall not apply to waters pumped or flowing from coal mines where the coal or culm, or refuse have been removed therefrom; or shall not prevent the discharge of sewerage from any public sewer, owned or maintained by any municipality in this Commonwealth.
>
> "Section 2. Any person, firm, or corporation violating the provisions of this act shall be deemed guilty of a misdemeanor, and shall upon conviction be punished by a fine of one hundred dollars for each offence, and a further fine of fifty dollars per day for each day the offence is maintained, or be imprisoned not exceeding one month, or both, at the discretion of the court."

This act has not been enforced for the reason that to no State Department has the duty of enforcement been delegated. More than this, legislation so drastic, affecting as it does the operating conditions of a large and valuable industry, should be interpreted only after thorough consideration and with accurate knowledge of conditions. Practical alternatives should be found before the coal mining companies are forced to discontinue their present practice, and to that end the investigations hereinafter detailed were undertaken, the purpose being to discover whether it was advisable to enforce compliance with the act and, if so, what disposition, other than discharging culm directly into the streams, would be reasonably applicable.

The act, if rigidly enforced, would perhaps result in benefit to the anthracite region and to riparian owners on the watercourses leading therefrom, but it does not provide for purification of streams to such an extent that they could be used for water supply, as it specifically permits the discharge into the streams of mine water carrying sulphuric acid and other impurities. Where streams receive sewage,

mine water may be beneficial and act as a germicide or neutralizing agent, but where they are pure, both mine water and mine refuse should, so far as possible, be excluded. Mine water with its acid increment is unfit for domestic use and steam generation, and near the mine destroys fish life. Dilution, due to increased volume received from tributaries, reduces the acidity, and each of the rivers into which acid water is discharged passes through limestone areas that exert neutralizing influences.

The act does not apply to the bituminous region, and the investigation has therefore been confined to the anthracite region where conditions were known to be more serious. The principal mine contamination of the streams in the bituminous region is from mine drainage or from wash water used to reduce the percentage of sulphur in the fine coal before coking, but the streams are not used to carry away the smaller particles of coal as in the anthracite fields. One of the coke companies is experimenting now with a view of recovering the acid as a by-product.

Recommendations

We recommend the enforcement of the above Act of Assembly by alternative methods, in individual cases, at the option of the mining companies, subject to approval by the Water Supply Commission, and suggest that hydraulic mine filling be adopted wherever geological and mining conditions make it feasible; also that in portions of the field where the workings are on a pitch too steep to make this practicable, settling basins or other suitable provision be made to remove the solids, and the effluent then be passed through well constructed filters, as is now the practice at a number of the collieries in the Schuylkill region.

Most minor streams would, to a large extent, clear their beds of mine waste within a few years, if the supply of culm was discontinued, but to restore the river channels to their original carrying capacity, immense amounts of mine waste would have to be dredged from pools, eddies and the slack-water above dams. The expense of removing this material may in part be offset by the marketable nature of some of the coal recovered, as shown later in discussing river coal recovery operations.

Definitions of Terms Used

CULM. Fine coal which passes through smallest screen in dry process breaker and is generally deposited on a bank, either by cars or scraper line.

SILT. The finest particles of culm; also a mixture of culm with sand or clay.

SLUSH. Water and waste material from a washery or from the wet side of a breaker, which is conveyed to the mines or to a slush bank or otherwise disposed of through pipes or troughs.

WASTE WATER. The drip from the washery or breaker; also the effluent from slush banks.

SLUSH BANKS. Deposits of fine coal and waste material from a washery or wet side of a breaker, being accumulations of solids by sedimentation from slush.

MINE WATER. The drainage or pumpage from a drift or mine, which carries a very small percentage of solids but contains variable quantities of sulphuric acid.

ROCK. Slate, bone or other waste material of the size of chestnut coal or larger. (Material that will pass over a $\frac{3}{4}$ inch square mesh.)

CULM BANK. A pile of fine coal and waste material from a dry process breaker.

CULM DEPOSITS. Dust, fine coal and waste material deposited by streams, either in their beds, upon their banks, or on the low-lying flats subject to overflow.

Present Methods of Culm Disposal

The meaning of the term "culm" as applied in the anthracite mining industry has undergone various modifications as the market conditions have changed. In the early years of mining the effort was to produce coal above the size of what is known as "chestnut" (over $1\frac{1}{4}$ inch square mesh screen) and rakes were used in the mine to separate the larger coal, the fine coal and dust being left in the mine, for at that time only rock and breaker waste was deposited on culm banks on the surface. As the demand for "chestnut" coal increased and "pea" coal (through $\frac{3}{4}$ inch and over $\frac{1}{2}$ inch mesh) was marketable as a domestic size, all fine coal was loaded out of the mine and "mountains of culm" became prominent at the collieries of the anthracite region.

About 1890 the use of smaller mesh grates and forced draft at steam plants created a demand for sizes smaller than No. 1 buckwheat (through $\frac{1}{2}$ inch and over $\frac{1}{4}$ inch mesh), and the value of the small sizes in the old culm banks warranted some of them being reworked. For this purpose the "wet process" or "washery" was developed, and

serious pollution of the streams of the anthracite region followed, no general effort being made to dispose of the slush from these operations. This condition continued until the beds of many streams were choked with culm, which subsequent floods deposited on farm lands along the shores, causing direct damage to riparian owners and also increasing the damage from freshets.

Numerous lawsuits and verdicts for damages against the coal companies induced them to make some effort to keep the culm and slush out of the streams. The early devices employed were crude and inefficient, and in a good many instances they have not been materially improved.

The various methods of disposing of slush from "wet process" breakers or washeries are:

1. Direct discharge of all waste into the nearest stream or watercourse.

2. Discharge to a slush bank with sides built of dry culm with a sluiceway of plank at the lower end, through which the water is drawn off. This water carries the fine particles and dust and is very dirty, depositing black mud on the banks of the streams. The banks retaining settled material frequently give way, causing the rush of culm to the streams.

3. Receptacles similar to the above, with the addition of mine rock around the bank to act as reinforcement and coarse filter. By this method most of the coarser material is retained on the bank but the effluent is black and carries fine coal in suspension.

4. Settling basins. These have been constructed in various ways and numerous devices have been used to precipitate and remove all solids from the slush. In some instances the results are satisfactory, while in others scraper lines or elevators keep the contents of the basin so disturbed that the effluent is black, only the coarser material being removed by settlement. Part of the material thus recovered is marketed to briquetting plants and the remainder stored for future use.

5. An efficient method is to line the surrounding rock bank, mentioned in the third method, with ashes and cinder from the boiler rooms to form a fine grained filter in addition to the firm support of rock. This, when carefully made, gives a clearer effluent than the other methods mentioned above.

6. Hydraulic mine filling, commonly known throughout the region as "flushing" or "silting," consists of flushing the culm back into worked-out portions of the mine with water, and was first used in

1884 in the Schuylkill region for extinguishing a mine fire at an intermediate level on the main haulage slope, after repeated failures to quench it with large quantities of water sent down intermittently. About 1886 or 1887 this system was introduced in the Lehigh and Schuylkill regions for the purpose of sealing off mine fires, arresting "squeezes" and supporting the surface. In 1891 it was put into systematic use at the Black Diamond Mine of the Plymouth Coal Company at Luzerne, for surface support and to permit the recovery of coal from pillars. About this time a party of foreign engineers visited Pennsylvania and studied the process, afterwards highly developing it in several European coal fields, in some cases using sand and other materials besides culm.

Hydraulic mine filling serves many beneficial purposes about a mine, viz:

A. Extinguishing mine fires. This practice has become common and proved effective, particularly in old workings which are more or less obstructed by falls or caves.

B. Arresting mine squeezes. When a squeeze starts from heavy overburden and close first mining of pillars, if a section of sufficient area in advance can be filled with culm, the movement can be permanently arrested.

C. Supporting the surface. Hydraulic mine filling has played an important part in supporting the surface, particularly where it was covered with valuable buildings or streets of a town.

D. Reclaiming pillars and increasing yield. Hydraulic filling has been used for this purpose in the Northern Field since 1891, and in several instances mines which would otherwise have been abandoned as exhausted have been kept active and hundred of thousands of tons recovered without serious surface disturbance. When such filling has been used, the workings are left in a much more secure condition than would have been possible had only the wooden props and timbers incident to first mining been left in the abandoned workings.

E. Disposal of spoil banks, reclaiming land for buildings. Mine filling has furnished a means of disposal of the waste from the reworking of old culm banks, and in some cases where the need was urgent whole banks have been hydraulicked into the workings. In others, the commercial sizes have been screened out, and only the fine coal washed into the mines. Huge banks have thus been disposed of, and in some cases the slate and bone have been ground up and included with the culm, so that in this manner valuable land has been entirely cleared for building purposes.

F. Preventing culm from getting into streams. Where the waste from washeries and wet breaker preparation is returned into the mine, stream pollution is reduced. The mine filler, mixed with from 60% to 90% of water, is run by gravity in troughs, when possible to a shaft, borehole, slope, crop fall, or cave hole through which it is introduced into the mine. When circumstances preclude direct gravity troughs, the filler is raised by elevators, conveyors or pumps to the required height. Wrought steel or iron or cast iron pipes carry the material down the shaft or slope or from a borehole, lined at top and bottom with pipe. From the foot of the borehole the filler is conveyed through pipes to the head of a range of chambers and allowed to flow into each chamber through sections of pipe controlled by valves. Wood stave pipe is frequently used in the distribution, as it wears well, is practically acid proof, and is lighter and easier to handle. Bulkheads of mine props notched into floor, roof and ribs, tightly boarded with plank and sealed with manure, straw or dirt, act as dams at the foot of the chambers to confine the filler. A finely screened wooden box, or pipes, at various heights, must be provided to draw off the water if the bulkhead is made tight. The necessary strength of the bulkhead is directly proportional to the height and pitch of the vein.

Various methods used in filling the workings are:

INDIVIDUAL. In this system the filler is discharged directly into each chamber and is generally used in flat workings.

PANEL. In this a number of chambers are isolated and simultaneously filled, usually leaving one or more unfilled between panels for the purpose of ventilation, traveling ways or drainage.

COLLECTIVE. In this method, adopted in pitch of chute workings, the filler is led to the highest point and allowed to find its way into all the working below. It contemplates reopening the gangways and airways by roads driven along the high rib and necessitates the rehandling of considerable filler.

The best practice, whatever system is used, calls for intermittent operation, to allow water to drain off and the filler to settle and become solid, for proper drainage is most important in hydraulic mine filling.

If the regular mine equipment is not large enough to handle the drainage water as well as the normal mine water, this must be increased and arrangements made for clearing the sumps, as there is sure to be a quantity of fine silt brought down from the filled sections.

Hydraulic mine filling cannot be applied economically in all conditions. In steep and narrow basins the cost of building adequate bulkheads is prohibitive if the object of refilling is for the extraction of coal alone. When the veins are of sufficient thickness and other conditions are favorable, the collective method may be used and the sections reopened by driving new gangways and airways in the pillars on the upper side of the old roads.

If a property extending up a long anticlinal is opened in the basin or lowest point, the upper workings will pass beyond the level which can be reached by filling. Should it be deemed advisable to fill such a section, the filler must be pumped or elevated to crop holes or boreholes on the outcrop. If this is not possible, some other filler such as sand and gravel must be used, as is now contemplated by one of the mining companies in the Wyoming region. As culm will settle on a pitch of about five degrees, it is occasionally impossible to fill entirely very flat workings.

As under modern mining methods only a small proportion of the coal is waste, only a limited area can be filled. This is why all the accessible culm or other refuse should be returned to the workings, where it will be most beneficial.

In any method of disposing of mine waste the possible present or future value of culm as fuel demands consideration. As the price of coal advances and as improved methods are adopted for utilizing the finer sizes of anthracite or coal associated with gangue material, either in boiler fire boxes or in gas producers, the possibility of obtaining fuel from this waste material demands consideration. Therefore, the disposal of coal for mine filling or other purposes will, to a large extent, be influenced by the value which this offers as a fuel, available for either present or future needs. At the present time, owing to the improved method of preparation, very little anthracite is wasted. Rice size is now obtained, No. 1 being the grade that passes through a screen 1/16 to 1/32 inch mesh, and No. 2, the grade that passes through a screen 1/32 to 1/64 inch mesh.

In the following pages are given descriptions of the condition of all streams in the anthracite region which are impregnated with culm; descriptions of the operations at each colliery and washery, with the method of disposal of culm and mine water, and descriptions of river coal recovery operations.

CHAPTER II

DESCRIPTIONS OF STREAMS IN THE ANTHRACITE FIELDS

The condition of the various major streams draining the anthracite region is here epitomized, and under these general heads the condition of the individual tributaries is presented.

LACKAWANNA RIVER

The Lackawanna River rises in Ararat Township, Susquehanna County, near the Wayne County line, and enters the Northern Anthracite field two miles above Forest City, at which point the watershed has an area of 45.2 square miles, and the water is suitable for domestic supply. From Forest City the river flows through the eastern half of the Northern Field for 37.1 miles, and discharges the entire drainage from this section into the Susquehanna River at Pittston.

The Lackawanna Valley is narrow and the tributaries which rise in the mountains on either side flow by a direct course to the river. Thirty-eight of these carry culm and mine water from 67 collieries and numerous mine openings to the Lackawanna River. Along its entire course in the Anthracite Region this river is paralleled on one or both banks by railroads, the fills and embankments being composed largely of culm and mine waste. Most of the collieries are located along these railroads and much of the flatland, subject to flood, has been utilized for deposits of culm, ashes and mine waste, which in times of high water are washed into the bed of the stream and carried into the Susquehanna River. In this manner the channel has been filled to a depth of from six or eight feet, thereby increasing the flood area and damage.

From Forest City to Carbondale the river is swift and the channel narrow, and although the water is black with culm little is deposited. Below Carbondale the channel is choked with culm, and in the dry seasons would have the appearance of an ordinary slush bank, were it not for the large volume of mine and waste water discharged into the stream.

Meredith Brook (No. 2)

Near the mouth at the Lackawanna River the water is clear, and there are no culm deposits at this point, although some culm banks around Forest City Colliery drain toward it, but from a borehole

mine water is pumped direct to this brook. At the first main road crossing three drifts were found, one belonging to the Pennsylvania Coal Company and two to the Delaware & Hudson Coal Company, but no drainage runs from them to the brook. In places the brook is troughed under mine railroad tracks or culm and rock banks, the wash from which is slight except during heavy rains. Beyond these banks the water looked clear, but receives a stream of mine water from No. 2 Shaft, Pennsylvania Coal Company, and above this shaft the brook is free from all pollution. On one branch a reservoir of the Penusylvauia Coal Company supplies drinking water to the collieries. The bed of the brook is in good condition, free from debris, etc., while its banks are well formed and sodded, thereby preventing wash.

Trout Creek

Above the dam which stores wash water for the Clinton Falls Colliery this stream is clear. At the colliery, about a quarter mile further downstream, slush and waste water carry in culm and blacken the stream. From an adjacent culm bank more culm is washed into the creek. From this point down to the junction with Clarks Creek the bed is full of culm and numerous deposits appear on its banks.

Clarks Creek (No. 3)

From the source to the junction with Trout Creek the stream is clear of mine water and culm pollution. Immediately below the crossing under the New York, Ontario & Western Railroad a new channel has been dug, skirting the edge of the hill to the south and entering the Lackawanna River at a point a short distance below its old mouth. Coal is mined so close to the surface that flooding of the mines was feared.

Stream (West side of Lackawanna River, between No. 2 and No. 5 creeks)

The source of this creek is under a culm bank, loose culm being scattered about its headwaters. At present the only contamination comes from a few old rock and culm banks near the stream which are washed on their edges by it. Near its mouth the stream enters a culvert and discharges clear water into the Lackawanna River.

Creek (Empties into Lackawanna River on east side just above Creek No. 6)

This stream shows several small deposits of culm and ashes, which proved on inspection to have been washed in from the Delaware & Hudson Railroad fills which cross it. Above these fills the stream is clear.

Elk Creek (No. 6)

Rises near the site of the old Richmond No. 4 Colliery, the most northern tributary running parallel to a culm bank for 300 feet, but only reaching it when swollen by rains. The tributary from the Buffalo Breaker runs under a culm bank where it gathers culm and ashes. Below this branch the creek bed is rocky, the stream of considerable size, and the banks of sufficient height to prevent overflowing in most places. The gravel bed retains some culm and the banks show a few small deposits, 10 or 12 square feet in area. The current becomes swifter and the culm deposits correspondingly fewer. The slope of the bed is again reduced near Simpson, where it receives sulphur water through a tributary from the Morss Hill culm bank. Mine water from the Delaware & Hudson openings near Coal Brook Colliery also drains to Elk Creek. At its mouth in the Lackawanna River Elk Creek contains practically no culm, but considerable sulphur.

Coal Brook (No. 7)

No culm deposits were found at the mouth at the Lackawanna River, but the brook is white with sulphur water from Coal Brook Colliery. A stream from the boiler house carries ashes and one from the pump house carries mine water to the brook. Above the culm banks, which are subject to wash, a stream of mine water from an opening enters the brook. At the forks in Coal Brook remain traces of an old culm bank, which will not affect the stream except by rain wash. Above this point the water is clear and pure, with rocky bed and well defined banks to the source in mountain springs.

Racket Brook

Both the left fork, which overflows from the Scranton Gas & Water Company reservoir, Lake Brownell, and the right fork are clear. From the old Racket Brook Colliery for a half mile downstream culm banks line the brook, so that the bed shows continuous culm deposits. Flowing through Carbondale, Racket Brook receives municipal wastes which it discharges into the Lackawanna River.

Fall Brook (or Crystal Brook) (No. 8)

Both the large branch coming from Crystal Lake and the small one from the Spring Marsh are clear to their junction above the Murrins Colliery. Waste water from this breaker runs direct to Fall Brook, but the culm deposit is not as great now as it was formerly when the washery was in operation. Neither at the Murrins nor Giles' Breaker, which is idle, are the culm banks washed by Fall

Brook. Except for a stream of mine water from a drift below Giles' Breaker, the brook is nearly clear, and the only culm deposit appears to have been washed in from the coal outcrop and strippings. At the mouth a small culm deposit seems to have been deposited by the Lackawanna River.

Devaneys Creek

At its source this creek is free from all pollution, as the water is clear and used for drinking purposes. It flows mostly through woods and ravines, and is said to become dry during the summer. At its mouth the creek forms a delta. There are a few small sand and culm deposits nearby which seem to have been deposited by the Lackawanna River at high water.

Creek (West side Lackawanna River, between Devaneys and No. 9 Creek)

The source of the creek is in mountain springs, clear and free from pollution.

Creek (No. 9)

This creek rises in a small spring about one mile from the Lackawanna River, and flows along the coal outcrop. Near the Thomas Walker Mines the creek flows over culm but without much erosion at ordinary stages because of its slow current. Along the creek banks more or less rock and culm are found.

Lees Creek (No. 10)

The branch which comes from mountain springs and swamps is free from pollution to the junction with the south branch. The south branch is free from pollution and is used for drinking purposes above the Delaware & Hudson No. 4 Tunnel, at which point a stream of mine water enters. Culm and rock are washed from a Delaware & Hudson rock bank. The creek follows the coal outcrop which appears and disappears along the stream as it approaches the breakers of the South End Coal Company and the Wachina Coal Company. Here the coal outcrop becomes more prominent and is worked in strippings by the South End Coal Company. From this point on the creek is carried in a flume to the Lackawanna River.

Next stream south of Sacandaga Colliery, tributary to Powder Brook

This stream is clear from the source almost to Carbondale, where it flows under a culm and rock bank near an abandoned opening, from which point down small culm deposits are found in its bed.

About 800 feet south of Sacandaga Colliery this stream runs into the same drain which carries the slush from the Sacandaga Colliery, and drains thence into the swamp which is the source of Powder Brook.

Powder Brook (No. 11)

This stream at its source is merely the drainage of mine water, slush and waste water pumped to the swamp by the Sacandaga and Bolands collieries. There is but little surface water draining to the swamp, so that the stream is composed almost entirely of sulphur water, black as ink, and full of fine culm. Two branches of Powder Brook entering from the left were nearly dry, but both were clear. The third branch on the left showed small deposits of culm on its banks and in its bed. About 1,200 feet upstream is an abandoned operation whose culm bank extends across the stream and drains directly into it. About 100 feet above the source of the brook is a rock and culm bank, atlhough it does not seem to affect the water, as the material is coarse. At the Powderly Colliery the mine water, waste water and leakage from slush pumps all run to Powder Brook direct. From the Erie Colliery (Pennsylvania Coal Company) a stream of waste water enters Powder Brook. Just below Erie Colliery, Powder Brook has its outlet in the Lackawanna River.

Shore Creek (No. 12)

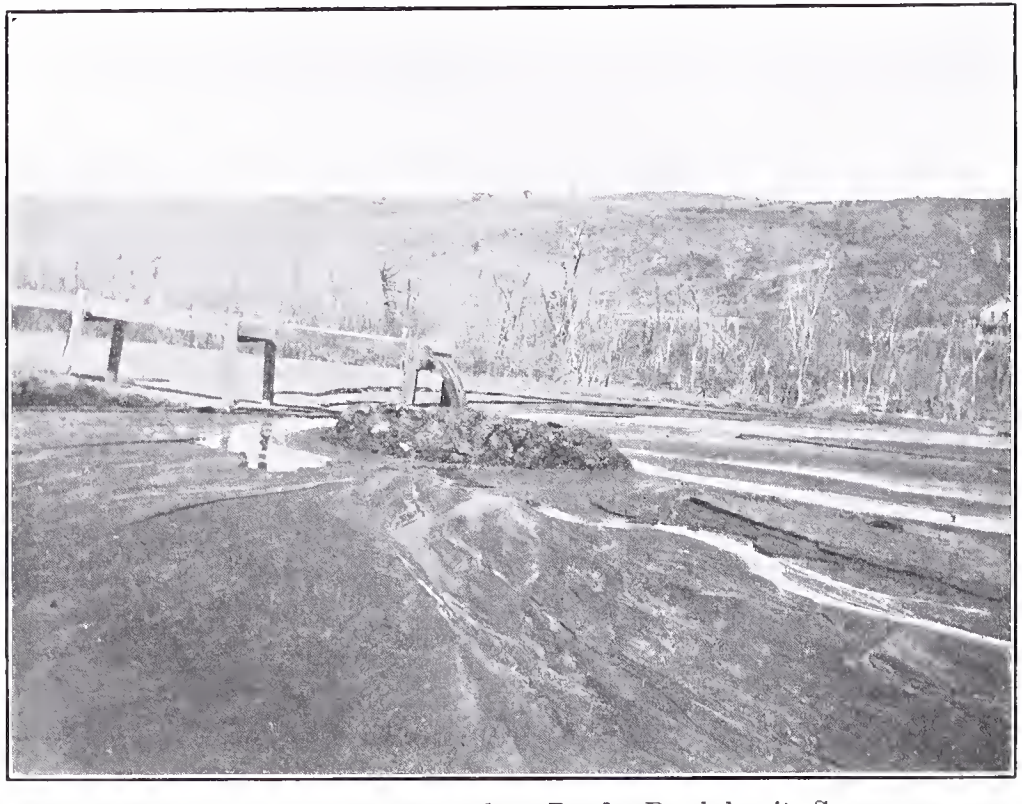
Owing to mine caves and workings most of the water from this creek is diverted into the Delaware & Hudson mines and reappears at No. 4 Opening, flowing into Lees Creek.

Creek (West side Lackawanna River, between No. 12 and No. 13 creeks)

This stream has its source in mountain springs, and near the headwaters the Erie and the New York, Ontario & Western railroads have built a dam and reservoir. The water is pure and free from pollution, but there is not much overflow from the dam at present.

Aylesworths Creek (No. 13)

Near the mouth at the Lackawanna River the water was nearly clear, although a few small deposits of culm were found on the bank. A stream of waste water carrying a little culm in suspension drains to the creek from the Keystone Breaker. Mine water from a Pennsylvania Coal Company opening drains direct to Aylesworths Creek.



Slush discharging into Swamp where Powder Brook has its Source

The creek bed shows small deposits of culm up as far as the abandoned workings of the Edgerton Coal Company, where two large culm banks, one 1,600 feet and one 300 feet long, are washed by the creek. From these banks up to the Erie Colliery and Water Company dams the stream is free of culm or mine water.

Rush Brook (No. 14)

The source of this brook is in Heart Lake, from which point down to the culm banks of the West Mountain Coal Company the brook is free from pollution. Culm deposition begins here, and although the bank is about 40 feet from the stream with a road between, culm is washed by rain across the road into the bed of the brook. The culm bank above mentioned is located on a side hill (pitch about 40 degrees) with drainage direct to stream. Preparation in West Mountain Coal Company is dry, so that there is no drainage to the stream from that source. Below this colliery there is a mine opening discharging mine water to Rush Brook, the quantity varying with the season. Further downstream the Fireside Coal Company Breaker runs a stream of waste water direct to Rush Brook, carrying with it considerable culm. Water in Rush Brook, which thus far has been clear, now becomes black and continues so. At Jermyn, a stream of mine water enters. Nearing the Lackawanna River the slope increases and there are no culm deposits in the main body of the brook. At its mouth, a large gravel bar lodges some debris but shows no culm.

Gardners Creek

Its source is in mountain springs and there are no collieries on the watershed, while only one rock bank is in the vicinity of the stream and this is not subject to wash. Mine water which runs to the creek from various openings along its banks is the only source of pollution. The Northwest Branch comes from a swamp and is clear, while the Southwest Branch is in about the same condition as the main stream. At the mouth, an ash bank deposited by a silk mill drains to the creek, and other debris, rubbish, etc., is thrown in just before it empties into the Lackawanna River.

Spruce Creek

This creek flows into the Lackawanna River at Jermyn. The first tributary entering from the right shows traces of culm, which have been washed in from a culm bank back of the Jermyn Colliery (Delaware & Hudson Coal Company) which drains into the creek. Above this bank this branch is clear. The main branch of Spruce Creek is

clear for a mile or more upstream. At a point where a culm fill crosses the stream a few small deposits are washed into the creek, but the headwaters of Spruce Creek, which are in a small swamp, are clear. By means of two small concrete dams and artificial channels, nearly all the water of two minor branches of White Oak Run is diverted into this swamp. These dams were built by the Archbald Coal Company and the Delaware & Hudson Coal Company to divert the streams from their original channels in order to prevent the flooding of their mines close by.

White Oak Run (No. 15)

Overflow from the dams on two minor branches (see Spruce Creek) flows to a reservoir at the Archbald Coal Company Breaker, where all water is used for washing purposes, and from which there is no overflow. The two main branches of White Oak Run are clear from their respective sources to the junction point. Just below the junction, the Delaware & Hudson Company has a reservoir, and about 300 feet downstream is a large reservoir of the Scranton Gas & Water Company. After receiving the waste water from the Archbald Coal Company's slush bank, White Oak Run becomes black from this point to its mouth, and both bed and banks show continuous culm deposits.

Creek (West side Lackawanna River, between No. 15 and No. 16 creeks)

This source is in mountain springs, and the water is fairly clear. A small branch entering contains sewage and other refuse but no culm is found in the bed.

Laurel Run (No. 16)

From its mouth up to the Olyphant Water Company's Dam, the run is clear of culm or other pollution. On a bluff above the dam two small streams of mine water flow from the Humbert Coal Company drifts and drain to Laurel Run, but this effect is almost negligible in such a large quantity of water.

Creek (No. 17)

This creek has its source in a swamp. Two rock banks on hill above creek are subject to wash after heavy rain, while two small streams of mine water run to creek No. 17 from the drifts.

Grassy Island Creek (No. 18)

Coming from the dams of the Scranton Gas & Water Company the stream is clear. Drainage from the slush bank and mine water at the Sunnyside Colliery (Humbert Coal Company) and wash from its

Waste Water from Culm Bank running directly into Grassy Island Creek

waste bank turn the creek black and fill it with culm. At the Dolph Colliery, Grassy Island Creek receives additional mine water and washes several large banks. Waste and mine water carry quantities of culm to the creek just before it empties into the Lackawanna River.

Creek (No. 19)

This stream is almost entirely composed of mine and waste water from the Riverside Colliery. The water is black, and the banks show ash and culm deposits above the culvert under the New York, Ontario & Western Railroad. A retaining wall along the Lackawanna River confines the creek and prevents any deposits of culm till after it enters the river.

Sterrick Creek (No. 20)

Near the mouth at the Lackawanna River the creek is full of rubbish, but contains no culm. From Grassy Island Shaft (Delaware & Hudson Coal Company) a stream of mine water enters and culm and rock banks drain to it. On the left bank some distance from the stream is No. 3 Shaft (Sterrick Creek Coal Company). No water drains to the creek, which is free from pollution at and above this point.

Wild Cat Creek (or Ridge Creek)

This stream has its source in the mountains and is clear till it reaches Raymond Colliery. Here the creek flows between and under culm banks, receives streams of mine water, waste water from the breaker and drainage from slush bank, which turn the water black and leave culm deposits on either bank. Wild Cat Creek joins Tinklepaugh Creek opposite the Borough of Winton.

Tinklepaugh Creek

Both East and West branches have their sources in mountain springs, the former being clear until it receives a stream of mine water from Sturgis Shaft, and the latter to the junction with the East Branch. The creek flows between culm banks of the Ontario Colliery, and, besides washing these, receives much culm with the slush from the Ontario Washery. Below the junction with Wild Cat Creek the stream is known as Millers Creek.

Millers Creek (No. 21)

Millers Creek is formed by the junction of Wild Cat and Tinklepaugh creeks. Near the mouth so much culm had been deposited as to necessitate the excavation of the channel, the stream being diverted to one side of the channel for that purpose.

Creek (No. 22)

This stream is clear to the Lackawanna Colliery (Sterrick Creek Coal Company) where it receives waste and mine water, turning it black before reaching the Lackawanna River.

Bulls Creek (No. 23)

This stream rises in the mountains and is clear spring water to a point about 600 feet below a small dam where mine water empties from a drift, turning the water yellow. Where the creek passes culm, ash and rock banks, cribbing or concrete walls have been built so that it does not wash the banks. The Lackawanna Coal Company has ash and rock banks along this creek. The creek through Olyphant is enclosed by concrete walls and culverts which extend to the Lackawanna River. No culm is found in the bed. This stream is said to be dry in the summer.

Eddy Creek (No. 24)

At the mouth in the Lackawanna River there are no culm deposits, but the creek water is yellow with sulphur. A short distance upstream the Delaware & Hudson Company has a dam to impound water for flushing ashes at the power plant, and a little farther up two pipes from the Delaware & Hudson workings discharge mine water into the creek, the water from one of these being red. Above the aforementioned ash dump the water in the stream is clear. Some mine water is found entering from an opening near the Underwood Colliery, while mine water from the Marshwood Colliery is pumped direct to the creek. The small streams tributary to Eddy Creek near the headwaters are all clear, but are dry in the summer.

Price Creek (No. 25)

This stream is clear from its source until it reaches the Johnson Colliery, where mine and waste water drain into it. From this point to the mouth at the Lackawanna River the creek bed is full of culm.

Pancoast Creek

Pancoast Creek, which is a tributary of Price Creek, is clear of culm from source to mouth, though it receives streams of surface water and sewage which discolor it.

Creek (No. 26)

Both main branches of this creek are largely street drainage and contain sewage, rubbish, etc. Into the right hand branch going up, mine and waste water from the breaker of the Price-Pancoast Coal Company is discharged, and a culm bank is washed by this stream farther down.

Smith Creek (No. 27)

From its source down to the Storrs Colliery the water is clear and unpolluted. Here slush and waste water from the Storrs Washery and Scranton Anthracite Brickette Works have filled the creek bed with culm. From this point down to the mouth culm deposits are continuous.

Creek (Between No. 27 and No. 28 creeks on west side of Lackawanna River)

This creek, which is clear until it reaches the culm banks, flows into a nearby pond and is used by the Scranton Traction Company in furnishing water to a small loader for boiler house coal.

Leach Creek

Leach Creek is clear from the source to Cayuga Shaft, where some mine waters enters it. From this colliery enough culm in the waste water reaches Leach Creek to cause the bed and banks to show culm deposits down to the junction with Leggitts Creek.

Leggitts Creek (No. 28)

This stream has its source near Clark's Summit, and is clear until it reaches an old colliery (name unknown) where culm from the banks washes to the creek. From this point down to Leggitts Creek Colliery the bed is filled with culm. At the latter colliery mine and waste water, carrying culm, run to the creek, so that the culm deposits are continuous from this point to the Lackawanna River.

Creek (No. 29)

This creek empties into the Lackawanna River just above the Manville Shaft, where the water is black and the bed is full of culm. Proceeding upstream, rubbish and street drainage were found entering and waste water from No. 1 Plane Colliery (Pennsylvania Coal Company), the latter carrying culm and silt with it. Above this colliery the water is clear.

Creek (West side of Lackawanna River, between No. 29 and No. 30 creeks)

This is a small creek which formerly drained the Hill Section of North Scranton but is now used as an open sewer. An ash bank and dump have been filled in across the old creek channel, which acts as a dam for sewage. There is no outlet from the ash bank, but the condition above it is very bad from a sanitary standpoint, although there are no culm deposits.

Roaring Brook (No. 30)

From its source to the workings of the Spencer and Nay Aug Coal companies the brook is clear spring water. Here, waste, mine water and slush discolor the stream so that it is black all the way to its mouth. Culm deposits are found all along the banks, on the flood areas, and near Luna Park a large one in the stream bed. At the Delaware, Lackawanna & Western Railroad Station a dam built across the brook has caused a large deposit of culm which the Lackawanna & Wyoming Valley Railway is pumping out to a small washery. All waste water is returned to Roaring Brook.

Stafford Meadow Brook

From its source, above the reservoir of the Scranton Gas & Water Company to its mouth, at the Lackawanna River, this stream contains neither culm nor mine water. Numerous streams of sewage enter it as the brook flows through the City of Scranton.

Keyser Creek (No. 31)

This creek is clear until reaching the Delaware, Lackawanna & Western repair shops, where it receives a quantity of oil and refuse. At Capouse Shaft the creek washes an ash bank and a culm bank and absorbs some sulphur. Much dirty waste and mine water enters the creek from the Archbald Colliery (Delaware, Lackawanna & Western Coal Company) and culm is run into the stream frequently, the deposits being numerous. A fertilizer plant opposite the Archbald Breaker drains directly to the creek. In most places, except near the Archbald Colliery, the stream is well confined to its channel. Here it seems to have overflowed and left considerable culm along shore for a distance of 75 feet from the bank.

Creek (No. 32)

Drainage from the slush bank at the Premier Washery (Premier Coal Company) is the source of Creek No. 32. The stream is black and full of culm, and receives several streams of mine water from openings of the Delaware & Hudson Coal Company before it flows into the Lackawanna River.

Spring Brook (No. 33)

Coming from the Spring Brook Water Supply Company's reservoirs, the stream is clear. When the brook reaches the property of the Du Pont Powder Company, it receives slush from the Pennsylvania Coal Company's Washery. Dry Valley Run, which empties into Spring Brook, is clear.

Lidys Creek

This is clear from the source to its mouth at Mill Brook. The Pennsylvania Coal Company pumps water from it for boiler use.

Mill Brook (not Mill Creek) (No. 34)

Above the Spring Brook Water Supply Company's reservoir the water is clear, but just below the dam the brook washes over the coal outcrop, and the stream absorbs some sulphur from contact with rock and culm banks on the way down. At Heidelburg No. 1 Colliery (Lehigh Valley Coal Company) mine water and waste water enter, and these are sufficient to discolor the stream. Drainage of slush from the Pennsylvania Coal Company's Washery helps pollute the stream, while the Langcliffe Colliery also discharges waste water directly to the brook. A stream of very dirty water carrying much culm from the slush dam of the Pennsylvania Coal Company's No. 9 Colliery also enters, as well as the waste water from the Central Colliery. This brook flows directly into the Lackawanna River and carries considerable culm.

Pyne Creek

From its source in mountain springs the water is clear and pure. At the Pyne Colliery, mine water and some waste water drain to the creek, which, after washing the edges of rock banks, becomes discolored. It flows into St. Johns Creek.

St. Johns Creek

This creek is clear till joined by Pyne Creek. It flows by and washes banks of the Sibley Colliery (Pennsylvania Coal Company) and Jermyn No. 1 Colliery (Jermyn Coal Company). From wooden sluiceways of the slush bank at Jermyn No. 1, a large quantity of culm is washed into the stream and carried into Rade Brook.

Rade Brook (No. 35)

From the source in the mountains this brook is clear until it receives mine water from old workings of the Austin Colliery, now torn down and abandoned. The brook washes culm and rock banks here

and carries some culm with it. After it is joined by St. Johns Creek, large culm deposits occur on either bank, in places 100 feet wide, left there when the brook overflowed. A stream of mine water enters from a Pennsylvania Coal Company opening. It washes a large rock bank near Old Forge Breaker, and three culm deposits of considerable size occur in the bed, but at the mouth the current is so swift that all culm is washed into the Lackawanna River.

Coal Brook (No. 36)

This stream is clear of pollution until it reaches the William A. Colliery, except for a little mine water and wash from a culm bank it skirts just above. After passing the William A., it carries quite a lot of culm and mine water and empties into the Lackawanna River.

Creek (No. 37) (Between Coal Brook and Falling Springs Brook)

This creek is clear at source, but later receives a stream of mine water from an old drift. Near the mouth it flows under a rock bank and empties into the Lackawanna River.

Falling Springs Brook (No. 38)

Both branches are clear, coming from the Spring Brook Water Supply Company's reservoirs on the mountain. As they near the Lackawanna River they flow into a swamp and there become contaminated with culm deposited by the Lackawanna River in time of high water. As there are numerous mine openings along the streams, it is probable that they contain sulphur at certain times in the year when they receive the drainage from these mines.

SUSQUEHANNA RIVER

The North Branch Susquehanna River enters the Northern Anthracite Field at Campbell's Ledge, the upper gateway to the Wyoming Valley, with the accumulated drainage of a watershed of 9,540 square miles, and about a mile below receives the waters of the Lackawanna River carrying immense quantities of culm and mine refuse. From this point to the bluffs below Nanticoke, the southern limit of the Wyoming Valley, practically every tributary adds its quota of culm from the various mining operations distributed over the valley. At the mouths of these streams extensive deltas of culm and mine refuse are deposited during periods of low water when the current in the river is sluggish, to be picked up by spring floods and dropped in eddies or the deeper pools of the river bed and on islands and rich alluvial flats, causing inestimable injury to the farm land

and increasing the flood damage in the cities and towns along its banks. In this manner the northern channel at Fish Island opposite the southern part of Wilkes-Barre has been completely choked, the deposit being 26 feet deep in places. At Richard's Island, opposite Plymouth, the east channel was so filled with culm that no water passed through when the river was five feet above low water mark. Much of this culm has been removed by the Plymouth Coal Company for hydraulic filling at the Dodson Colliery. A washery was also built on the east bank to recover merchantable coal from the deposit, but all the refuse and "slush" from this operation are returned to the river channel. Immense quantities of culm are deposited in the pool formed by the Nanticoke Dam.

Additional culm is discharged into the river by Black Creek and Shickshinny Creek at Mocanaqua at the western limit of the Northern Anthracite Field. From this point the Susquehanna River is entirely outside of the coal measures, but numerous tributaries bring to it the waste from the other fields.

Nescopeck Creek flows into the river at Nescopeck, carrying the waste accumulated from the Eastern Middle Coal Field by its principal tributary, Black Creek.

Catawissa Creek, rising in the southern part of the Eastern Middle Coal Field, is polluted with culm and mine water at its source. It soon passes out of the coal measures but carries its burden of culm for 30 miles through a rich farming district, and flows into the Susquehanna River at Catawissa.

Shamokin Creek, with its source near Centralia in the Western Middle Coal Field, receives drainage from the western half of this field and empties it into the Susquehanna River about a mile below Sunbury.

Mahanoy Creek, rising near Delano at the eastern end of the Western Middle Field, receives all the mine drainage from this region. It leaves the coal measures at Ashland, but receives additional mine drainage from Potts Colliery through Big Run at Barry, and also from the Trevorton Basin through Zerbe Run, which flows into it at the extreme western end of the field. From this point it passes through a farming district for a distance of about ten miles and discharges into the Susquehanna River a mile above Herndon.

Mahantango Creek receives a small amount of culm from two old banks and mine water from a drift or tunnel in Rausch Gap, near Valley View, Hegins Township, Schuylkill County, but there is no evidence of any culm in the stream where it flows into the Susquehanna River at Mahantango.

Wiconisco Creek is free from pollution until it reaches Tower City, between which point and Lykens quantities of culm are washed into it from a number of collieries on the steep mountain side to the north. A large bar of culm lies in the river at the mouth of this creek at Millersburg.

Swatara Creek receives most of the drainage from the western part of the Southern Field in the vicinity of Tremont, and there is a large amount of culm in the stream as far as Swatara Gap, ten miles above the mouth of Little Swatara Creek. Below this point the amount of culm constantly decreases, due to the slow current resulting from a very flat watershed and numerous dams, with long stretches of slack-water above them. No culm is noticeable where it discharges into the Susquehanna River nine miles below Harrisburg.

From below Plymouth, on the North Branch, to Columbia, on the main stream, numerous dredging operations recover thousands of tons of merchantable coal annually from the deposits constantly forming in the deeper pools.

Carpenters Creek (No. 39)

The present source of this creek is mine water from the New Schooley Shaft (Pennsylvania Coal Company) and the Exeter Colliery (Lehigh Valley Coal Company). It receives mine water and drainage from a slush bank at the Stevens Shaft and Washery which somewhat discolors the water. At the mouth in the Susquehanna River the creek is dirty in color and carries a small amount of culm.

Creek (No. 40)

The stream is largely street drainage from Pittston and the water is dirty and full of rubbish. In passing No. 3 Shaft (Pennsylvania Coal Company) it receives sulphur water but no culm, shortly afterward discharging into the Susquehanna River.

Tompkins Creek (No. 41)

Its source is a stream of mine water coming from old workings of the Fernwood Colliery, which later is joined by a stream of mine water from the Yost Colliery. At No. 4 Pennsylvania Shaft the creek runs under the boiler room where it flushes out ashes, and also receives a stream of mine water and washes a rock bank. It flows into the Susquehanna River at Pittston, carrying ashes but little culm.

Creek (No. 42)

Except for a little clear water, this stream is composed of mine and waste water drainage from No. 6 and Ewen collieries (Pennsylvania Coal Company). It is black and carries enormous quantities of culm, part of which is deposited at its mouth in the Susquehanna River.

Creek (No. 43)

Though a little clear water comes down from the mountains, mine water from openings of the Pennsylvania Coal Company is the main source of this creek.

Abrahams Creek (No. 44)

The main branch of this stream rises in a swamp back of the Mt. Lookout Colliery. Waste and mine water drain to the above swamp, but the effect of the culm bearing stream is not perceptible in the water of the swamp. A slush bank at the Westmoreland Colliery, mine and surface water from the Maltby Colliery and a slush bank at the Forty Fort Colliery,—all discharge direct to the stream and carry some culm. Part of the excess mine water from the Harry E. Colliery drains to the creek, although most of it reaches the East Branch Toby Creek. After receiving a stream of mine water from a borehole below the Stone Bridge it flows to the Susquehanna River, showing a few small culm deposits in its bed.

Lamp Black Creek

This creek rises in mountain springs, which usually run dry in the summer. Slush and waste water carrying considerable culm enter the stream at the Pickaway Colliery, turning it black, below which it flows under the Lehigh Valley Railroad cut-off and empties into Gardners Creek.

Gardners Creek

The main branch of this creek is clear from its source in the mountains to its junction with Lamp Black Creek. This tributary carries enough culm to badly pollute the stream. The East Branch is largely mine water from an opening near the old Boston Colliery (Pennsylvania Coal Company), though it flows over several culm laden flats before joining the main stream. Several small culm deposits were found in the bed of the main stream below the junction. At the Laflin Colliery (Delaware & Hudson Coal Company) the creek receives a stream of mine water and flows into Mill Creek at the Central Coal Company's Breaker.

Laurel Run (or Laurel Creek)

This stream, where it flows from the Spring Brook Water Supply Company's reservoir, is free from pollution, and the channel is well banked. At the Laurel Colliery (Delaware & Hudson Coal Company) the stream washes a rock bank, but receives little if any pollution from it. No. 5 Baltimore Colliery (Delaware & Hudson Coal Company) discharges several streams of dirty wash water containing some culm into the creek from which point the water is discolored to the junction with Mill Creek. A few small culm deposits, washed in from No. 5 Colliery, are found in the creek bed.

Mill Creek (No. 45)

The overflow from the Spring Brook Water Supply Company's reservoirs forms the main body of this stream, and all branches down to Paddens Creek are unpolluted. This latter stream carries a large quantity of culm from the Keystone Colliery and numerous deposits are found near the junction. Its tributary, Gardners Creek, is full of sulphur water and carries some fine culm. From the Central Coal Company Colliery a large amount of slush is dumped direct into the stream bed. It receives from the Delaware Colliery a stream of mine water; from the Pine Ridge Colliery, both mine and waste water; and from the Prospect Colliery, drainage from a slush bank. When it flows into the Susquehanna River the creek is black in color and carries some fine culm in suspension.

Toby Creek (No. 46)

From its source to the East Boston Washery in Luzerne the main branch of Toby Creek is free from pollution, but below this point it receives mine water and culm, the bed in places being covered with culm deposits and the banks showing traces of culm. Storm sewers from Edwardsville and Kingston drain to Toby Creek. The East Branch is contaminated at its source with mine water and culm from the Harry E. Colliery, and also receives some mine water, but no large quantities of culm, all the way to the junction with the main branch near the Woodward Colliery. The water discharging to the Susquehanna River at its month does not seem to carry much culm. Culm banks at the Harry E. and Pettibone collieries are washed by the East Branch, while the main branch washes banks at the East Boston No. 1 and Woodward collieries.

Creek (No. 47)

Mine water from the Boston Washery (Delaware & Hudson Coal Company) is the first contamination to reach this stream. A stream of dirty waste and mine water from Plymouth No. 3 Colliery (Dela-

ware & Hudson Coal Company) blackens the stream and fills it with culm. Additional waste and mine water from Plymouth No. 5 and Plymouth No. 2 collieries transport culm to the creek, while a large volume of mine water is pumped into it just before it empties into the Susquehanna River at Plymouth.

Browns Creek (No. 48)

Slush running directly from the Hillside Breaker (Bright Coal Company) is the first source of pollution of this creek. The settling tank for the waste water at No. 4 Washery (Delaware & Hudson Coal Company) removes most of the culm, but it is claimed that the silt accumulating in this tank is flushed to Browns Creek at night. The stream is discolored, but the current is so swift that most of the culm is retained in suspension. The only possibility of culm reaching Browns Creek at the Gaylord Colliery is stoppage in the slush lines leading to the boreholes, which would necessitate the slush being run direct to the creek. Most of the culm is carried into the Susquehanna River.

Coal Creek (No. 49)

This stream is clear from the source to the Lehigh and Wilkes-Barre openings near the outcrop, where mine water in considerable quantities is pumped into it. The stream empties into the Susquehanna River just below the Reynolds Shaft.

Empire Creek

Where this creek joins Solomons Creek, several large culm deposits are found. From the Stanton Colliery the creek receives mine water, surface water and some waste water draining from a slush bank, the last named bringing in considerable culm. The smaller branch leading from the Franklin Colliery contains mine water only.

Solomons Creek (or Buttonwood Creek) (No. 50)

Large culm deposits are found on the banks of this stream near its mouth. At the Buttonwood Colliery, it washes rock and culm banks, and receives a stream of mine water and some drainage from chutes of the Buttonwood Washery. Branch No. 1 is clear, although it runs under a rock bank at No. 5 Shaft. Branch No. 2 rises in woodland springs, and after crossing St. Mary's Road enters a concrete culvert, where it is polluted by sewage from a number of houses. Just above Buttonwood Colliery, where branches No. 1 and No. 2 unite, a large swamp extends as far as the Wilkes-Barre City line. In the swamp are large deposits of black mud which contain

culm. Inside the city line the creek receives a discharge from the Pennsylvania Sewer which carries surface drainage from a large part of Wilkes-Barre and refuse from several manufacturing plants. Most of the culm which enters is brought down by Empire Creek. The next branch above, St. Marys Creek, rises in springs near St. Mary's Cemetery and is clear to its junction with the main body. From the reservoir overflow at the Sugar Notch Colliery its tributary, Preston Creek, receives considerable sulphur water. Were it not for this mine water Preston Creek would be dry during the summer months. A small tributary flowing through Ashley and Hanover Township contains sewage but no culm pollution. Just below the Ashley Planes a small stream of mine water enters, but the main creek is free of culm deposits. From the fills of the Central Railroad of New Jersey the creek is clear to its source.

Creek (No. 51)

The East Branch of this creek is clear until it receives a stream of mine water from the Hadleigh Colliery. At No. 9 Colliery (Lehigh & Wilkes-Barre Coal Company), mine water, wash from culm banks and waste water all serve to discolor and pollute the creek with culm. In Sans Souci Lake large quantities of culm have been deposited and the water is dark in color. A large proportion of the culm is deposited before the creek reaches the Susquehanna River.

Warrior Creek (No. 52)

The North Branch is clear from the source to the abandoned Warrior Run Colliery, where a stream of mine water and wash from rock and culm banks enter it. Below this point the creek is carried in a flume to the Delaware, Lackawanna & Western property at the Truesdale Colliery. The Middle Branch is clear down to the Truesdale, where it receives mine water and waste water from the slush bank. A dam has been built across the creek to store wash water. At the junction of the North and Middle branches a few old culm banks are washed by the creek. From this point downstream the condition of both bed and banks is bad. Opposite the old Dundee Shaft, what was once a swamp is now a culm mire, which continues below the junction with the Bliss (or West) Branch. This West Branch is almost entirely composed of mine water, waste water and slush, from the Bliss and Auchincloss collieries, and is black and loaded with culm. Just below the crossing of the main road a new channel has been made which carries the creek direct to the Susquehanna River, instead of parallel to it through the Borough of Nanticoke.

Culm Deposit in abandoned Pennsylvania Canal draining directly into Shickshinny Creek

Newport Creek (No. 54)

The North Branch of the creek above the Susquehanna Coal Company's No. 6 Colliery is clear. At this colliery the slush, waste and mine water discolor the stream and fill the bed and banks with culm. All the way from this colliery down, the condition of the bed and banks of the North Branch is very bad. Near the Stearns Shaft (Susquehanna Coal Company) two streams of mine water enter it. At the Nanticoke Washery streams of waste and mine water enter the creek carrying still more culm and silt, while the slush banks drain to it under the Pennsylvania Railroad tracks. Just below the Washery the North and South branches join. It is claimed that along the Pennsylvania Railroad near Nanticoke the North Branch has filled up over a foot in the past four months, and that continual raising of the tracks is necessary. The Middle Branch is clear from its source to the junction with the North Branch. The South Branch is clear from its source to No. 3 slope (Lehigh & Wilkes-Barre Coal Company) where a stream of mine water enters, and some rock and ash banks are washed by the stream at a point near the site of an old breaker. Mine and waste water at the Wanamie No. 18 Colliery (Lehigh & Wilkes-Barre Coal Company) turn the South Branch black and small deposits of culm are found in the creek below the slush bank. At the Alden Colliery, drainage from the slush banks and mine water run to the South Branch. The Susquehanna Coal Company's No. 7 Colliery dumps some slush, waste and mine water direct to the South Branch, and the creek bed is full of culm below this colliery. The slush bank discharges into both branches near their junction and carries considerable culm.

From the junction of the North and South branches down to the Susquehanna River the stream is filthy, the banks showing practically one continuous culm deposit and the deposits on the bed in places are several feet in depth. All slush, waste and mine water from No. 5 Susquehanna Colliery enter near the mouth and carry a large quantity of culm into the Susquehanna River at Nanticoke.

Shickshinny Creek (No. 55)

This creek is clear to a point about 200 feet from its mouth in the Susquehanna River, where it receives drainage of the Salem Breaker (E. S. Stackhouse Coal Company) through the Pennsylvania Canal.

Black Creek (No. 56)

Above Lee's Shaft, Black Creek is clear, part of the water coming from mountain springs and the rest draining from a swamp. Mine water from an opening near Lee's Shaft and the wash from a large

culm bank are the first sources of contamination. Below this point a wooden box culvert conveys the creek to a reservoir for storing wash water. From the slush bank at the West End Colliery a stream of culm bearing waste water enters Black Creek, which then discharges into the Susquehanna River at Mocanaqua.

Cross Creek

The East Branch of Cross Creek coming from Freeland, though full of sewage, is free from culm or mine water pollution until it reaches Drifton Colliery, where it receives mine water just before uniting with the West Branch. From this same colliery, the West Branch, which was formerly clear, obtains waste water, culm and mine water, while a stream of mine and waste water runs to Cross Creek from Jeddo No. 5 Colliery, causing culm deposits on the banks and bed of Cross Creek. Some distance below, Cross Creek empties into Big Black Creek.

Lattimer Canal

This watercourse was built to drain mine water from the Drifton and Lattimer collieries and to prevent flooding of the stripping nearby. The springs which formerly fed Little Black Creek now run to the canal, which is clear until sulphur water is pumped in from a stripping of the Drifton Colliery (Lehigh Valley Coal Company). At Lattimer No. 4 the canal is well banked and waste and mine water enter it from the washery, while some of the water is pumped out for washing purposes. After receiving waste water from Lattimer No. 4 and No. 3 collieries the canal shows culm, although the current is so swift that no deposits are noticeable. Additional waste and mine water enters the canal from the Harleigh Colliery, carrying some fine silt. The Lattimer Canal discharges into Big Black Creek just below the Harleigh Colliery.

Little Black Creek

The portion of the old creek bed below the Lattimer strippings usually carries some surface water from the vicinity of Milnesville, though in dry seasons no water is flowing. Culm was deposited in the creek bed in the past when it drained the Lattimer Collieries, but no silt reaches it now. This stream empties into Big Black Creek below Milnesville.

Eagle Run

This stream is clear from its source to Harwood. Just below the Harwood Colliery mine water and waste water from the breaker discolors the stream and fills it with fine culm. In places this stream

Culm in Big Black Creek near Jeddo

is carried around the coal outcrop in wooden boxes to prevent flooding of the strippings, but returns to its natural channel a short distance below. Along the banks at frequent intervals are culm deposits which extend from 25 to 50 feet from the stream. Mine water from some of the Cranberry openings drains to Eagle Run before it enters the ravine through which it discharges into Cranberry Creek.

Cranberry Creek

Though clear at its source, the water is soon polluted by waste and mine water from the Hazleton No. 1 Colliery, which discolor the stream and load it with fine culm. The stream flows between low culm banks subject to wash, and also receives drainage from the Hazleton No. 1 slush bank. Eagle Run brings in still more culm, while the deposits near the junction with Cranberry Creek are extensive. Waste water and mine water from Cranberry Colliery serve to further pollute the stream. Boyds Run, Long Run and Stony Creek are all clear tributaries, although the second shows traces of sulphur from flowing over the coal outcrop. Cranberry Creek empties into Big Black Creek.

Big Black Creek

The source of Big Black Creek is a stream of waste and mine water from the Eckley Washery (Coxe Brothers & Company). Deposits of culm are found along the banks below the washery. By means either of a wooden box or an earth embankment the creek is confined to its channel through the property of G. B. Markle & Company. Cross Creek carries into Big Black Creek a quantity of culm from Drifton and the workings above. From the old Ebervale Washery down to Jeddo No. 7 the creek runs in its old channel and shows numerous culm deposits on either bank. At the Harleigh Colliery, before the present earth embankment was built, a large quantity of culm was deposited on the flood area just below the junction of Big Black Creek and the Lattimer Canal. This latter stream is very dirty and carries quantities of culm into the creek. Cranberry Creek with accumulated drainage from the watershed of Eagle Run brings culm and mine water from Hazleton No. 1, Cranberry and Harwood collieries. Another dike has been thrown up at the Black Ridge Colliery on the north side to prevent flooding. For a mile the current is rapid, which prevents any deposition of culm. At Tomhicken Shaft, Slope No. 5 of the Hazle Mountain Coal Company and Derringer Shaft, streams of mine water flow to Big Black Creek. Roberts Run, carrying mine water from the Gowen openings, is the last tribu-

tary polluted either by culm or mine water to enter Big Black Creek. From Gowen down the creek flows through very mountainous country, the banks are high, and the flood areas negligible. There are three dams on Black Creek,—at Rock Glen, Gowen and Zenith. Big Black Creek joins Nescopeck Creek at Tank.

Nescopeck Creek (No. 57)

This stream is clear of culm or mine water from its source to its junction with Little Nescopeck Creek. The latter stream receives the discharge from the Jeddo Tunnel, which is all mine water. Black Creek, which empties into Nescopeck Creek at Tank, is still black in color, but much of the culm has been deposited. About a mile above the mouth a few culm deposits are found on the banks. At the mouth in the Susquehanna River there are two culm deposits,—one possibly 50 by 100 feet and the other 200 by 100 feet.

Hunkidori Creek

The source of this stream is the overflow from the reservoir of the Honeybrook Water Company near McAdoo, and the water is clear till polluted by a stream of mine water from No. 20 Slope (Lehigh & Wilkes-Barre Coal Company). A dam has been built across the stream to store wash water for Honeybrook No. 5 Colliery. About 1,000 feet below the colliery this stream empties into Catawissa Creek.

Beaver Brook

This brook rises in a field near Audenreid and is clear until it receives the waste and drip water from the Beaver Brook Colliery. Mine water from slopes No. 5, No. 10 and No. 11, as well as drainage from the slush bank, turn the stream black and fill it with culm. A new channel has been built for the brook from the state road at Audenreid to a point about a quarter of a mile above the mouth in Catawissa Creek, to prevent flooding workings through mine caves which are frequent under the old bed.

Scotch Run

Above the McCauley Mountain Colliery this stream is clear, winding through the woods for most of its length. Mine water now drains to the run, as will also waste water when the colliery recommences operations. A pump is installed at the run to supply water for the boilers and for washing purposes when mine water is scarce. It flows into Catawissa Creek.

Catawissa Creek (No. 58)

Mine water pumped out from old workings of the Springbrook Colliery (Lehigh Valley Coal Company) is the source of the principal branch of the stream. At the Springbrook Washery (Lehigh Valley Coal Company) streams of waste water and overflow mine water serve to pollute the creek, discolor it badly, and fill it with culm. The other branch from McAdoo contains sewage and rubbish, but no mine water nor culm. Drainage from No. 5 Colliery (Lehigh & Wilkes-Barre Coal Company) carries more culm and mine water to the creek, already badly discolored. Hunkidori Creek receives mine water and empties it into Catawissa Creek. Beaver Brook, the next large tributary, carries quantities of culm in suspension and is of sufficient size to turn the main stream black and cause numerous culm deposits. Shortly after this junction Catawissa Creek passes out of the coal measures near the Water Level Tunnel (Lehigh & Wilkes-Barre Coal Company). All other tributaries between the coal outcrop and the mouth in the Susquehanna River, with the single exception of Scotch Run, are clear. This run drains the isolated McCauley Mountain basin, and contains mine water, though little culm. A mile above Mainville, and again at the town, two fields about 100 feet wide have been ruined by culm deposited on them in times of flood. A dam near Catawissa has caused culm to be deposited in the stream bed, forming numerous small islands of fine coal and silt. Where Catawissa Creek empties into the Susquehanna River lies a culm deposit, which in time of high water is nearly submerged.

Locust Creek

The East Branch of Locust Creek is clear from its source to a point just below the first highway crossing near Locust Gap, where are found deposits of culm, partly from the Monitor Colliery, which has long since ceased working and been torn down, and partly from the slush bank at Locust Spring Washery. Most of the pure water in the West Branch of Locust Creek is retained in the small reservoir of the Philadelphia & Reading Coal & Iron Company, but at West Spring Slope a stream of mine water enters the creek just below this reservoir. At Locust Spring Colliery waste and mine water carrying culm turn the stream black and load it with fine silt. Just below the Locust Spring Washery the East and West branches unite, and from this point the creek flows swiftly through a narrow ravine, washing the bottoms of rock and culm banks, until joined by the branch from the Alaska Colliery, where culm is deposited over quite an area. Locust Creek at its mouth in Shamokin Creek has deposited a bar of culm and mine rock, some pieces of the rock being 6 to 8 inches in length.

Excelsior Creek

The North Branch of Excelsior Creek (sometimes dry) is conveyed through a wooden trough over mine caves and under a rock bank. At ordinary stages a concrete catch basin retains all the water from the Middle Branch, which is used as a boiler supply. The reservoir on the Right Hand Branch retains all of this stream as a supply for the Corbin Colliery. The bed of this creek is full of culm deposits which are washed into Shamokin Creek at certain seasons by the overflow from the reservoirs.

Quaker Run

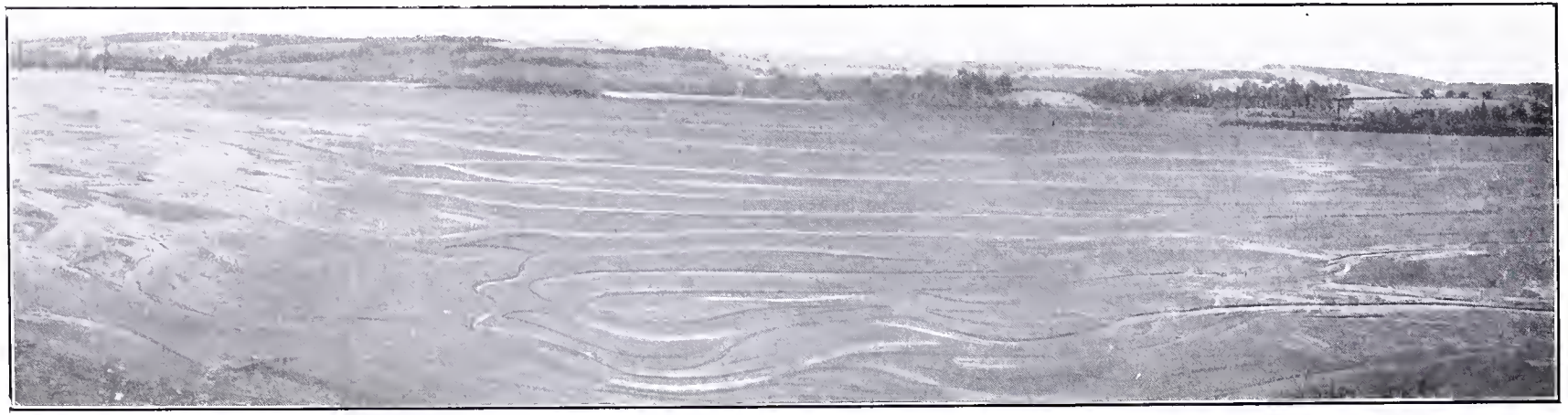
This stream originates in chute drainage and seepage from the slush bank at the Greenough Colliery, is discolored, and carries culm from the source. At the Scott Colliery, waste water and slush bank drainage help to fill the channel with culm. From Hickory Ridge Colliery, a small stream of sulphur water, free from culm, drains into Quaker Run which shortly afterward divides a part of it discharging into Shamokin Creek and the rest into a cave under the Buck Ridge slush bank.

Coal Run

Mine water from the workings of Richards No. 4 Colliery is the source of this stream. At the Natalie Colliery waste water carrying culm serves to further pollute the stream. A large culm deposit occurs above the Hickory Ridge Colliery, while just below the drainage from the slush bank has formed another. The waste waters from slush banks and breakers of the Hickory Swamp, and Colbert and Luke Fidler collieries are black and all carry fine culm to Coal Run. From the Borough of Shamokin the run collects rubbish and sewage, which it empties into Shamokin Creek. From Hickory Ridge Colliery to the mouth no large culm deposits were found, but a number of culm banks are washed by the run.

Carbon Creek

On the watershed above the Bear Valley Colliery this stream is clear and full of fish. At the colliery two streams, one of waste water carrying culm and another of clear mine water, pollute the creek and turn it black. Numerous small deposits of culm occur from this point down to the mouth. Burnside Creek is a small tributary which is largely waste and mine water from the Burnside and Sterling mines. After receiving rubbish and sewage from the Borough of Shamokin, Carbon Creek discharges into Shamokin Creek.



Culm Deposit on Flat near Deibler, on Shamokin Creek

Shamokin Creek (No. 59)

Considering its volume of water, amount of culm in suspension, proportion of mine water, the flood area covered with culm deposits and its general condition as a whole, this stream is the worst in the entire Anthracite Region. It is one of the few creeks in which the coal and culm is so extensive as to make coal recovery from its bed commercially profitable. From source to mouth the creek is black, the current in places is swift but as a rule sluggish, and the bed has became so full of culm that the channel is entirely obliterated and the stream spreads out over a vast area, depositing the fine culm that has been washed along by the current above.

Both the South and Middle branches are clear at their respective sources, but each receives mine water before their junction. The Middle Branch is polluted also by waste and mine water from the Sayre Colliery which discolor the stream and deposit culm on its banks. After the union of these two branches the creek flows through the Borough of Mt. Carmel, where it gathers additional culm and refuse from the Reliance Colliery. Beyond Mt. Carmel, at the junction with the North Branch, occurs an enormous deposit of culm, varying in width from 200 feet to a quarter of a mile. The North Branch is polluted at its source, which is mine and slush bank drainage at the Midvalley No. 2 Colliery. Midvalley No. 1 Shaft contributes mine water and Richards' Colliery waste and mine water full of culm to the North Branch. Green Ridge Creek carries culm to the North Branch from the mud elevators at the Pennsylvania Colliery, leaving a large culm deposit at its mouth. The first tributary below the union of the North and Middle branches, called Locust Creek, contains a quantity of culm from the Alaska and the Locust Spring collieries, and as its current is rapid, most of this material is carried into Shamokin Creek. The Enterprise, Corbin, Buck Ridge, Bergen-Ryan, Henry Clay and Cameron collieries and the Big Mountain Openings all drain directly into Shamokin Creek, bringing to it quantities of fine silt, while the Greenough and Scott collieries discharge their refuse to Quaker Run; the Natalie, Hickory Ridge, Hickory Swamp Washery, Colbert and Luke Fidler collieries drain to Coal Run; the Bear Valley and Burnside collieries and the Sterling Openings run to Carbon Creek, all of which carry their quota of fine culm to Shamokin Creek. Either directly or through tributaries, 25 collieries and washeries discharge culm, waste and mine water to Shamokin Creek between its source near Centralia and where it leaves the coal measures at Shamokin. The creek leaves the Borough of Shamokin through a narrow ravine, through which the current is swift and the culm is not permitted to

settle. At Reed and Deibler the flat area which was formerly rich bottom land is now merely an enormous culm deposit, even the highway which joins these two towns being swept by the culm in flood times. At Snydertown the channel of the creek has again become well defined and the current fairly rapid. From this point to the mouth in the Susquehanna River at Sunbury there are small deposits of culm in the eddies and on the banks.

Waste House Run

This stream is free from contamination down to the reservoirs of the Philadelphia & Reading Coal & Iron Company, which in dry seasons retain the entire flow. The first contamination is mine water from the Knickerbocker workings. A dam in the stream deflects part of the water to the wash water reservoir of the Maple Hill Colliery. Just below this dam the stream receives waste and mine water from the Ellangowan Colliery, and from this point to the mouth the water is black and carries fine culm. Mine water enters the run from the St. Nicholas and Suffolk workings. A dredge has been operating in the stream bed near its mouth, taking out some of the culm and piling it on a nearby bank. Waste House Run empties into Mahanoy Creek.

Shenandoah Creek

Mountain springs east of Shenandoah are the source of this stream, although much of the time these are dry owing to the mine workings being so close to the surface. At the Indian Ridge Openings the course of the creek has been changed to prevent flooding, while mine water, which has been used in flushing at Shenandoah City Colliery and is still black, is pumped to the creek. Kehleys Run, a small tributary, brings in quantities of culm from Kehley's Run Colliery. Near Shenandoah City Colliery a dam retains nearly all the water, which is used for washing purposes, and the bed below is dry except for the breaker waste water. Sewage from Shenandoah enters the stream nearby. The Cambridge Colliery discharges nearly all of its slush to the creek which at this point, is already loaded with culm. At each succeeding colliery, a dam across the creek retains wash water, which is used and later returned filled with culm. The swift current enables the stream to keep this culm in motion and prevents it from clogging the channel entirely. West Shenandoah Colliery, the Hudson Washery, Weston Colliery, Packer No. 4 and William Penn Colliery, all send their waste water, full of culm, to the stream. Opposite the Packer No. 1 Shaft the creek is in a very bad condition, in that the channel looks more like a

slush bank than a stream bed. Girard Creek, a small tributary, after receiving slush from Girard Mammoth Colliery and waste water from the Hammond Colliery, empties its silt-laden water into Shenandoah Creek. At Packer No. 5 Shenandoah Creek receives another stream of mine water, after which it flows into Mahanoy Creek.

Big Mine Run

This stream is clear until it reaches the culm bank near Centralia Shaft, where the waste water from that colliery fills it with culm and discolors it. After flowing by several rock banks, from which it gathers refuse, the current becomes very swift. At the Bast Colliery two streams of mine water and one of waste water reach the run, which by this time is loaded with culm. Big Mine Run empties into Mahanoy Creek.

Cat Run

Cat Run is clear down to the culm banks of the old Preston No. 1 and No. 2 collieries, but below these banks shows sulphur contamination although no visible tributaries of mine water are observable.

Highlanders Run

Near the source a stream of mine water from an old drift more than doubles it in size. In addition to the silt which enters with the drainage from the slush bank of the Potts Colliery, culm is washed down from the rock and waste banks. A dam is built to retain the water in dry weather for washing purposes. The run is black and carries culm when it empties into Big Run.

Big Run

This stream is clear until contaminated by the drainage from the Potts Colliery, part of which enters directly and the rest through Highlanders Run. After flowing through a narrow ravine for about a mile, where the current is swift and culm deposits small, Big Run empties into Mahanoy Creek at Barry. A flat meadow near the junction is completely overspread by culm.

Zerbe Run

The West Branch receives its first contamination from the slush bank at the North Franklin Colliery. Heavy rains wash quantities of culm from the slush bank into the run, although the ordinary effluent carries little silt. Mine water is collected in a dam from which wash water is pumped to the breaker. The overflow from this dam is later joined by waste water from the settling tanks and mud

elevators of the North Franklin Colliery which carries culm. The East Branch, which meets the West Branch at Trevorton, is perfectly clear. Some distance below the town a flat has been entirely covered with culm. At the Katherine Colliery culm reaches the stream with the breaker waste water and slush bank drainage. From this point to the mouth the current is swift and carries most of the silt into Mahanoy Creek.

Mahanoy Creek (No. 60)

Directly or through its tributaries this stream receives waste and mine water drainage from 40 collieries and washeries. It is impossible to estimate the vast quantity of culm reaching it annually, which, while rapidly decreasing in the size of the coal, does not seem to diminish in bulk. Deposits of culm are practically continuous in the main stream and its largest tributary, Shenandoah Creek, from source to mouth, filling up the channel, covering the banks and settling on the rich bottom lands within the flood area. The source of Mahanoy Creek is near the unused slush bank of the old Buck Mountain Colliery, where dirty mine water discharges from a manway to the stream bed. Culm deposits occur on the south side of the creek for about half a mile. The waste water from the Buck Mountain Colliery slush bank is black and carries culm in suspension. Mine water from the workings of the Primrose Colliery is the source of the Middle Branch. In the bed of the creek, from this colliery to Mahanoy City, culm deposits occur, apparently washed there when the Primrose Breaker was in operation.

The Middle Branch empties into the main body at the east end of Mahanoy City, the water at the mouth being yellow but containing no culm in suspension. The North Branch at its source is composed entirely of waste water and slush bank drainage, and is black and full of culm. Large deposits are found in the bed at and below the slush bank of Park No. 2 Colliery. Mine water from the Springdale Shaft, North Mahanoy Colliery and Mahanoy City Colliery drain to the North Branch. Waste water from the tanks and elevators at the North Mahanoy and Mahanoy City collieries carry fine silt to the stream. Just below the latter colliery the North Branch empties into the main body through a culvert under Mahanoy City. Beyond Mahanoy City the creek flows through culm banks continuously for over three miles, gathering silt at every turn. From Tunnel Ridge Colliery waste water, full of culm, drains into the creek. A half mile below this colliery the coal companies operate a dredge which removes culm from the bed of the stream, piling it on the bank. Drainage from the slush bank at the Boston Run Colliery carries much silt. At the mouth of Waste House Run another dredge is

taking silt from the creek bed. The Gilberton, Draper and Stanton collieries all discharge their waste water and slush bank drainage to Mahanoy Creek. Passing Mahanoy Plane the creek bed is full of culm, especially at the eddies where the silt is piled several feet deep. Mine water from Bear Ridge collieries No. 1 and No. 2 and the Girard Colliery drain into the creek, causing further pollution, although a new channel has been dug for the creek between the two last mentioned places to prevent the current from washing a large culm deposit in the old bed. Shenandoah Creek, laden with culm, flows into Mahanoy Creek at Girardville, causing numerous deposits below its mouth. Big Mine Run, which discharges into the creek, is very dirty and carries culm, while Locust Run with its mouth at Ashland is all mine water. Below this last junction Mahanoy Creek turns south and flows out of the coal measures. For some distance below Ashland the current is swift and the culm deposits less frequent, but at Gordon the stream again becomes sluggish and from this point to Barry the deposits on the flat areas are extensive. At the covered bridge near Taylorsville and again near Helfenstein occur culm deposits of considerable size. From Helfenstein to Dornsife the creek flows in the bottom of a narrow valley, keeping its regular channel. Below Dornsife the silt deposits, while frequent, do not extend more than 30 feet from the stream. Several piles of coal, varying in size from chestnut to rice, have been removed from the creek by the farmers. At the mouth of Mahanoy Creek in the Susquehanna River a huge culm bar, varying in depth between 5 and 8 feet, extends a considerable distance into the river.

Mahantango Creek (No. 61)

Rausch Creek is the only tributary of this creek that is contaminated by mine drainage, for mine water is the source of its West Branch. Just above the junction with its East Branch, which is clear, Rausch Creek receives more mine water from the drainage tunnel of the Brookside mines. Old culm banks of the Valley View Colliery (abandoned) are subject to wash by rains, but little culm is noticeable in the stream bed. At Valley View Rausch Creek empties into Pine Creek, which flows to Mahantango Creek at Klingerstown. Near the town of Mahantango the latter creek empties into the Susquehanna River, clear of culm but containing some sulphur.

Wiconisco Creek (No. 62)

The creek heads in the watershed above Tower City and is clear until it is joined by a black stream of waste and mine water from the West Brookside Colliery (Philadelphia & Reading Coal & Iron

Company). Below this point the current is rather sluggish and the general condition is swampy. At Williamstown two small streams of dirty waste water run from the Williamstown Colliery (Susquehanna Coal Company), causing the channel of the creek to be choked with culm and the adjacent areas to be flooded. From Williamstown to Lykens the creek flows in a well formed channel, slowly in places, and has a few culm deposits on its banks but none over 50 feet from the stream. At Lykens, Bear Valley Creek brings in mine water from the Short Mountain Openings, while the slush bank drainage and breaker waste water serve to carry still more culm to it. Near Short Mountain the banks show riffle deposits of culm, the water is black, and culm is constantly washed downstream. From here to its mouth at Millersburg the creek keeps well within its banks, and although the bed is covered with fine culm, the channel is open. The creek empties into the Susquehanna River at Millersburg, after depositing considerable silt on the flats between the railroad and the river.

Panther Creek

Mountain springs are the source of this stream, which is soon polluted by mine water from No. 4 Water Level Tunnel (Lehigh Valley Coal Company). At the Blackwood Colliery a stream of waste and mine water and slush bank drainage bring down silt. A large culm deposit below the slush bank has existed for some time, as the creek has cut a definite channel through it. At the end of this deposit Panther Creek empties into Swatara Creek.

Good Spring Creek

The source is mine and waste water at the Good Spring Colliery, black and carrying fine culm. At No. 3 Slope and again at Donaldson streams of mine water, but free from culm, enter the creek. Gebharts Run, a tributary with its mouth at Tremont, contains a little mine water brought to it by a branch called Middle Creek. Good Spring Creek empties into Swatara Creek a mile below Tremont.

Lower Rausch Creek

This stream is clear to the Philadelphia & Reading Coal & Iron Company's pumping station, where it receives mine water. Culm banks near the abandoned workings of the East Franklin Colliery are subject to wash in times of high water, while at the Rausch Creek Washery the creek receives mine water. Lower Rausch Creek empties into Swatara Creek, carrying mine water but no culm.

Lorberry Creek

Coming from the breaker drainage of the Lincoln Colliery, this stream is black and contains fine silt. Stumps Run brings to it culm from the slush bank effluent, and also washes a large rock bank. No culm deposits of any extent are found, as the current is swift and the channel narrow. About two miles below Lincoln, Lorberry Creek empties into Swatara Creek.

Swatara Creek (No. 63)

This stream is clear down to its junction with Panther Creek, where it becomes black in color and carries culm. From Dundas No. 6 Tunnel to Good Spring Creek all the tributaries are clear. This latter stream is black and carries culm in suspension and has a small culm bar at its mouth. Lower Rausch Creek, the next large branch, is polluted with mine water but no culm, while Lorberry Creek brings down both. Swatara Creek from its source to the mouth of Lorberry Creek, the last polluted branch, flows swiftly through a narrow ravine; the overflow areas and the accompanying culm deposits are negligible. Near Pinegrove the creek is black, carries quantities of culm, and shows considerable deposits on the banks and in the bed. In Swatara Gap there are a number of dredging operations which are recovering coal for domestic use. At the Jonestown bridge, just above the mouth of Little Swatara, the water begins to clear and the deposits of culm are less frequent. On reaching Quittapahilla Creek the stream bed is about clear of culm, although a few fine particles lie on the banks; and at Middletown, where the creek empties into the Susquehanna River, there are no indications whatever of culm.

LEHIGH RIVER

The Lehigh River, rising in Sterling Township, in the southern part of Wayne County, forms the boundary between Monroe and Carbon counties on the east and Lackawanna and Luzerne counties on the west, through the Pocono Mountains. It is a clear mountain stream available for water supply to a point about five miles below White Haven.

At no point does the Lehigh River flow within the coal measures, but it receives culm and mine water from several of its tributaries between White Haven and Mauch Chunk. Pond Creek empties into the river five miles below White Haven, carrying culm and mine water from the northern part of the Eastern Middle Field.

Laurel Creek, a small stream from the same region, contains some mine water but no culm.

Quakake Creek empties into the Lehigh River at Penn Haven Junction, carrying quantities of culm from the southern half of the Eastern Middle Field.

Nesquehoning Creek, the last of the culm bearing tributaries, enters the river at Coalport with the drainage from the eastern portion of the Southern Field.

Above Mauch Chunk the channel of the Lehigh River is narrow and the swift current carries mine waste into the pools formed by the Lehigh Coal & Navigation Company's dams at Mauch Chunk, Parryville and Lehigh Gap, from which two dredging companies recover approximately 45,000 tons of merchantable coal annually. Thousands of tons of fine culm are dredged from the canal by the Lehigh Coal & Navigation Company. About 20% of the material removed is merchantable coal,—the balance fine culm or silt,—and is immediately returned to the river, thus keeping the water black, and forming great bars which in places reach half way across the channel.

The last dredging operation on the Lehigh River is at Treichlers, below which point the silt is gradually settled, resulting in clear water at Allentown during ordinary stages of the river, but in times of flood large quantities of culm and silt are carried into the Delaware River.

Sandy Run

At the headwaters of this stream, Highland No. 2 Colliery discharges excess mine water and waste water, discoloring and filling it with culm. At the Sandy Run Colliery the run receives waste water carrying quantities of culm, besides additional accumulations from the washing of rock banks. From the last of these rock banks to the mouth of Mill Hopper Creek, a clear tributary, Sandy Run is a mass of culm, part of it deposited years ago but since picked up and redeposited farther downstream. About 2 miles below the Sandy Run Colliery occurs a second large deposit, three-fourths of a mile long and 300 to 500 feet wide. Beyond this flat the channel of Sandy Run becomes narrow, the current rapid and the culm deposits disappear, which condition persists to its mouth in Pond Creek.

Pond Creek (No. 64)

This stream rises above Upper Lehigh in the vicinity of coal strippings of the Upper Lehigh Coal Company. Traces of culm are found in the bed, probably from an old breaker which stood nearby. At the Upper Lehigh Colliery, waste water from a settling tank, which contains quantities of culm, enters the creek and leaves large deposits. As mine caves had occurred under the old creek bed, a dam and new channel were built which diverted the water to the so-called North Canal. Opposite Freeland a ditch was dug to drain

the small fresh water streams that formerly reached Pond Creek. A reserve dam of the Upper Lehigh Coal Company extends between the two canals, and just below this dam the creek returns to its old bed. At G. B. Markle & Company's upper dam Pond Creek is diverted, partly to the North Canal and partly to the South Canal, both branches carrying water full of culm and mine water. The culm deposit above the dam through which the creek flows is of considerable extent. The Markle Canals are about 8,000 feet long and from 150 to 1,400 feet apart. Between them is a culm deposit 7,500 feet long and from 75 to 700 feet wide, washed there when the Upper Lehigh Dam broke a few years ago. At Markle's lower dam the two canals again join and enter the old creek bed. Pond Creek flows past three abandoned breakers,—the Old Pond Creek Colliery, Fred Brandmaier's, and Pond Creek Shaft, where rock and ash banks are subject to wash. From this point down the creek has a well formed channel and the culm deposits are small and infrequent. Sandy Run discharges culm and mine water to Pond Creek, which then flows swiftly for two miles and empties into the Lehigh River.

Laurel Run (No. 65)

A short distance below the springs which feed the stream a large deposit of culm extends over the lowlands, washed there when the Old Buck Mountain Breaker was in operation. Three streams of mine water from old openings are the only pollution now reaching the stream. Laurel Run empties into the Lehigh River, carrying to it mine water but no culm.

Hazle Creek

At Hazleton Shaft Colliery this stream receives its first pollution in the form of excess mine water and drainage from the settling tanks. These discolor the creek and cause it to carry in suspension considerable fine silt. The creek is flumed from the colliery downstream for nearly three miles, and in order to keep the channel clear men are employed to shovel out the silt. After leaving the flume, the creek spreads out over a flat from 100 to 200 feet wide and deposits culm. At Ashmore the creek is joined by a drainage stream from the Hazle Brook Colliery which is loaded with culm, part of which is deposited at the junction. From Ashmore down the deposits of culm in the eddies are frequent but small, as the current is swift and most of the silt is kept in suspension. Dreck Creek, the largest tributary, is clear of culm or mine water pollution. The first stream to the left below Dreck Creek obtains mine

water from No. 5 Slope of the Hazle Brook Colliery. Numerous culm deposits appear at the heads of the islands and eddies in the creek. Hazle Creek joins Beaver Creek at Hazle Creek Junction and forms Black Creek, the principal tributary of Quakake Creek.

Beaver Creek

In wet seasons mine water is pumped from a drift into the headwaters of Beaver Creek, but at times the North Branch is dry as far down as the Jeanesville Colliery, where waste water from the settling tanks and overflow mine water discolor the creek and load it with culm. A huge deposit of culm is found in the creek bed a quarter of a mile below the colliery, and shortly below it is flumed to carry the water across a mine stripping. At the point where the North Branch turns due south an earthwork dam was built to divert the stream into a newly dug channel and so prevent flooding another stripping. Below an old abandoned washery, where it is joined by the South Branch, the stream resumes the old channel. Mine water pumped from a borehole is the source of the South Branch, which then receives quantities of culm from the Coleraine Colliery that have been sufficient to fill up the bed and cover the banks. At the junction of the North and South branches the condition of Beaver Creek is very bad.

When Beaver Meadow is reached the deposition of culm is in places over 700 feet wide and all vegetation within that limit is extinct. Drainage from the Beaver Meadow and Evans collieries brings down more culm and mine water to the already overloaded creek. Culverts allow part of the water in the creek to pass under the Lehigh Valley Railroad tracks, although it has been necessary to raise the tracks 5 feet within the past few years to prevent flooding by culm. At the Penn Forest Breaker the stream has returned to its natural width, the deposits of culm are less frequent, and the current swifter. About a mile below is the junction with Hazle Creek which forms Black Creek.

Black Creek

The union of Hazle and Beaver creeks, each of them black and carrying some fine silt, is marked by a deposit of culm. Down as far as Weatherly the current is rapid and the deposits of silt few. At Black Creek Junction this stream empties into Quakake Creek.

Quakake Creek (No. 66)

From its source as far as Hudsondale this stream is clear of mine water or culm pollution. Here a tunnel from the workings of the Coleraine Colliery empties mine water into the creek. It is joined below Black Creek Junction by Black Creek, which discolors the creek and carries into it some culm. At Penn Haven Junction, Quakake Creek discharges into the Lehigh River, carrying culm and mine water.

Nesquehoning Creek (No. 67)

Drainage from the New Hauto Washery furnished the first contamination to this stream. Culm banks at the Old Washery and below the New Washery are subject to wash by the creek in times of flood. The Lehigh Coal & Navigation Company have dams at the New Hauto Washery, the Summit Storage Yard and the Nesquehoning Colliery to impound wash water. Below the Hauto Washery the stream is dirty and a few small culm deposits are found. Dirty waste water and slush bank drainage from the Nesquehoning Colliery carry quantities of silt to the creek. Hell Kitchen Run, which empties in at Nesquehoning, has been much reduced in volume, as strippings near its source retain all the water. Below this branch the channel of the main stream is half choked with culm deposits 4 to 6 feet deep. About a mile from the mouth the slope of the bed becomes steeper, the channel is well defined, and the culm deposits disappear. The drainage tunnel from the Nesquehoning Mines discharges quantities of sulphur water into the creek just above its mouth in the Lehigh River.

SCHUYLKILL RIVER

The Schuylkill River, with its principal tributaries, Mill Creek, Norwegian Creek, the West Branch and Little Schuylkill, drains about three-fourths of the Southern Coal Field. Mine water from an old drift near Tuscarora is the source of the main stream, and eleven tributaries above Port Carbon, including every stream of importance, contain sulphur water, while five of them are loaded with culm.

Mill Creek, black with culm and mine water, empties into the Schuylkill River at Port Carbon.

Norwegian Creek carries culm and mine water from the region north of Pottsville and joins the Schuylkill River just south of that city.

The West Branch of the Schuylkill, including its tributaries the West-West and Muddy branches, drains the western central portion of the Southern Field, emptying its quota of culm and mine water from ten collieries and six mine openings into the Schuylkill River at Schuylkill Haven.

The Little Schuylkill, the last of the culm bearing tributaries, drains the eastern part of the Southern Field, including Tamaqua, and empties into the main stream at Port Clinton.

The Schuylkill River passes out of the coal measures just south of Pottsville. Above Port Carbon the watershed is steep, the channel narrow, and the current swift, with little opportunity for the de-

posit of culm except in occasional eddies. Below this point the gradient is less, the stream more sluggish, and the flood area greater. Between Schuylkill Haven and Reading frequent dams of the Schuylkill Navigation Company form long stretches of slack-water where culm is deposited.

In addition to an annual recovery of 60,000 tons of merchantable coal by 17 dredges operating in pools, where the deposits of culm are from six to eight feet deep, quantities of silt are removed by the Navigation Company in keeping the channels of the canal and river open. Below Reading the water is comparatively clear except in time of flood, when it is black as far as Philadelphia.

The flood areas at Schuylkill Haven, Landingville, Auburn, Hamburg and Shoemakersville show deposits of culm in varying amounts on the flats. In some cases the culm has ruined rich farm land, besides filling up the river channel and increasing the flood damage.

Tarmans Creek (No. 68)

The stream overflows from a small clear reservoir due south through some culm banks at the old Tuscarora Colliery, receives sulphur water from some of the old drifts, and runs through the Borough of Tuscarora into the Schuylkill River.

Swift Run (No. 69)

Coming from a small reservoir, this run is clear until it washes old culm bank and receives waste water from the settling tanks at the Maryd Colliery. The course of the run has been changed to prevent washing culm in the old bed. After two mine water streams from old workings enter, it empties into the Schuylkill River.

Big Creek (No. 70)

At the old Billeman's Colliery mine water from the drifts causes the first pollution to this stream. When the Schuylkill Lehigh Colliery is working, its drainage runs to Big Creek. Little Creek, containing sulphur but no culm, joins the former stream which then empties into the Schuylkill River, carrying sulphur water but no culm.

Kaska-William Creek (No. 71)

Mine water from the Kaska-William Colliery is the source of this stream, which remains yellow to its month in the Schuylkill River but carries no culm.

Silver Creek (No. 72)

There is no overflow from the large water supply reservoir except in rainy seasons, so at all other times the stream is composed of mine water and waste water from the Silver Creek Breaker and its slush bank. The water is black but contains little silt, as the slush bank drainage is clear. Silver Creek empties into the Schuylkill River.

Zacharias Run (No. 73)

Mine water from the Eagle Hill Colliery is the source of this stream. It also receives waste water from the breaker and slush bank, although the latter is nearly clear and does not contain culm. When the run empties into the Schuylkill River at Belmont it is black, but contains little silt.

Little Wolf Creek

Drainage from the slush bank at the St. Clair Colliery is the source of this stream, as the original springs which fed it were destroyed by strippings. Although the creek is black at the source, it does not contain much silt until the drainage enters from the Mt. Hope settling tank. This is full of culm and resembles a direct discharge of slush. After receiving sewage and rubbish in the town of St. Clair the stream empties into Mill Creek.

Mill Creek (No. 74)

Mine and waste water from the Middle Lehigh Colliery and its slush bank are the source of this stream. Just above the Morea Colliery is a deposit of culm about 300 feet wide, which has probably been washed down from the Middle Lehigh culm and slush banks. The settling tank at the Morea Colliery drains with the mine water to the creek, but much of the silt reaching the stream is washed in during high water from the waste banks. The swiftness of the current from this point to the mouth prevents any extensive culm deposits. From the Darkwater Colliery mine water runs into the creek, but as the breaker is not yet preparing coal there is no silt. At the St. Clair Colliery a dam impounds wash water, while the slush bank and settling tank drainage enter the stream with Little Wolf Creek. This latter tributary also obtains culm in the waste water from the Mt. Hope Colliery. From the Pine Forest openings mine water reaches Mill Creek by its branch, Forest Creek. After washing banks at the Marion Colliery (abandoned) and leaving a few small deposits on its banks, Mill Creek empties into the Schuylkill River at Port Carbon.

Norwegian Creek (No. 75)

Mine and waste water from the Howard Colliery, black in color and containing fine culm, are the source of the East Branch. At the Wadesville Colliery the slush bank drainage is nearly devoid of silt when it reaches the creek. The East Branch washes a number of culm banks, receives small streams of mine water, and unites with the West Branch just before entering a culvert which conducts it through Pottsville to the Schuylkill River. The West Branch starts with a stream of mine water from the Beechwood openings and receives three more streams of sulphur water before it joins the East Branch near Pottsville.

Buck Run

This stream originates in slush bank and waste water drainage from the Buck Run Colliery. The water is black and contains culm, particularly after heavy rains which wash silt from the banks. It empties into the West Branch Schuylkill River.

Butcher Creek

The stream is clear until it receives mine and waste water from the Juggler Colliery, which is black but contains little culm. The creek gathers quantities of culm by washing the banks at the Juggler and Ellsworth collieries, and a little fine silt with the settling bank effluent at the latter. Butcher Creek is black and carries a little culm in suspension when it empties into the West Branch Schuylkill River.

Minersville Creek

Drainage from the Pine Hill Colliery and the Emperor Washery, black and full of culm, is the origin of this stream. It is troughed by the Wolf Creek Washery, which when working empties in slush directly. A culvert carries the stream under Minersville and discharges it into the West Branch Schuylkill River.

West Branch Schuylkill River (No. 76)

The stream is clear above the Glendower Openings, where it receives mine water pollution and washes the foot of an old culm bank. At the Richardson Openings and again at the Oakdale Openings old waste banks are subject to wash by this stream. Buck Run brings in culm and mine water from the Buck Run Colliery, which turn the West Branch black and load it with silt. Near the Anchor Washery mine water enters the river and several waste banks are washed during wet weather.

The drainage from the Pine Knot Colliery, black and carrying culm, reaches the West Branch below the breaker, after which the water is badly discolored. At Mine Gap, Butcher Creek, which is also black and full of culm, empties into the West Branch. Where the drainage from the Oak Hill Colliery flows into the river, considerable culm has been deposited, appearing like black mud. The next polluted tributary, Minersville Creek, discharges the waste silt from three operations to the river below Minersville, increasing its already heavy burden of culm. The flats near this junction for 100 feet on either side have been submerged by recent floods and show numerous deposits of culm. A short distance below the channel becomes narrower and the areas subject to overflow much smaller. At Westwood the West-West Branch brings down its quota of culm to the river, almost doubling the quantity of water flowing in the West Branch. From this point down the river winds through a very narrow valley, and the current is uniformly rapid notwithstanding a number of dams built for power purposes. At Beckville most of the water is diverted to a grist mill and returned to the old channel a quarter of a mile downstream. Between the two mills the bed is nearly dry. Near Cressona the West Branch is again used to furnish power for a mill. The West Branch empties into the main body of the Schuylkill River at Schuylkill Haven.

West-West Branch Schuylkill River (No. 77)

This branch is clear till joined by Lytle Creek, which is black and carries a little silt, sufficient to discolor the main stream. Mine water from the Lytle Shaft and the tank at Phoenix Park No. 3 and drainage from the slush bank at the latter all reach the West-West Branch, increasing the acidity of the water and the amount of culm in suspension. Deposits occur a short distance below the colliery at bends in the stream. Just above Llewellyn more deposits on the flats were found. The Muddy Branch, which joins the West-West Branch below Llewellyn, is black and carries culm from the Otto Colliery. Beyond this junction the West-West Branch flows through a wooded country, with few overflow deposits on the banks but many in the bed, and at Westwood empties into the West Branch.

Muddy Branch Schuylkill River (No. 78)

Near its source this stream receives mine water from a drift belonging to the Philadelphia & Reading Coal & Iron Company. Waste water from the settling tank at the Otto Colliery is black and con-

tains suspended culm when it reaches the river, discoloring the water and filling it with silt. Another stream of mine water enters the river about half a mile below the colliery. From here to the mouth in the West-West Branch the Muddy Branch contains culm in its bed, but few deposits are found on the banks.

Panther Creek

This stream is nearly all mine water at its source: the Middle Branch contains a little clear water; the Right Branch is dry at times; and the water in the Left Branch is ordinarily retained in a reservoir of the Lehigh Coal & Navigation Company. Below the dam the stream is fed by mine water from No. 4 Openings. Near No. 5 and No. 6 collieries, besides the fine silt which enters with the slush bank effluent and breaker waste and mine water, quantities of culm are washed in from the banks during high water. At the No. 9 Openings culm and rock banks are subject to wash and mine water is pumped to the creek. From the dam opposite No. 8 Colliery, wash water is pumped to the breaker, but the creek is soon replenished by the waste water from the breaker and slush bank and mine water, black and carrying culm in suspension. The effluent from the slush bank at No. 12 Washery enters the creek above the dam from which the wash water supply is obtained. The dam has been nearly filled with culm deposits. The large slush bank between Coaldale No. 12 and Greenwood No. 15 washeries drains directly into Panther Creek, carrying silt in the effluent, and is subject to wash in time of high water. Bull Run, whose mouth is opposite this bank, is clear of culm pollution. Waste water from Greenwood No. 10 Colliery is black and carries fine silt to the creek. Near Rahn No. 11 Colliery the stream washes a rock bank continuously for half a mile, and by this time it is loaded with culm. Deep Hollow Creek, largely mine water but free of culm, empties into Panther Creek below this long rock bank. At the bends in the creek above the Tamaqua Colliery culm deposits are numerous but not large, the bed of the stream is full of silt, but the swift current keeps the channel open. Drainage from two slush banks and waste water from the Tamaqua Colliery further add to the culm already in the creek. When Panther Creek discharges into the Little Schuylkill River at Tamaqua it is black and loaded with culm and rubbish.

Wabash Creek

The source of this stream is just over the divide from the town of Tuscarora. An old slush bank near the Wabash Colliery (gone) is washed by the creek. Mine water from drifts at the old Newkirk

Colliery (gone) drains to the stream causing the first real pollution. The water of Wabash Creek is carried through a concrete culvert under the town of Tamaqua and empties into the Little Schuylkill River.

Little Schuylkill River (No. 79)

Though clear at its source, this branch of the river receives mine water from a drift at the old Silver Creek Colliery. By the time this stream reaches the Southern Field at Tamaqua the clear tributaries have eliminated the effect of the sulphur water. A dam near Tamaqua impounds water for the boilers at the Tamaqua Colliery. Between the dam and the pumping station a stream of mine water enters the river, and just below the pumping station more mine water flows in. Panther Creek brings in the accumulated drainage from the eastern part of the Southern Field, and is black and full of culm, while Wabash Creek contains mine water only. From the East Lehigh Colliery the river receives untreated slush and waste water loaded with culm. Numerous small deposits occur on the banks and in the bed, but the current is too swift to permit any large accumulations. Just below this colliery the Little Schuylkill River flows out of the coal measures. For 20 miles the river runs through a farming country, overflowing the flats at numerous points and depositing culm on the lowlands, but is still black and carries culm when it empties into the main body of the river at Port Clinton.

CHAPTER III

COLLIERY OPERATIONS

The conditions at the various collieries or mine workings which are found within the drainage area of the streams which receive water from the coal regions are described in detail in the following pages.

Stillwater Coal Co. (Abandoned)

This breaker is located on the outcrop above Forest City, about 250 feet from and west of the Lackawanna River. There is a small culm bank each side of the breaker, although nothing but rain water will drain from the banks to the river.

Clifford Washery, Pennsylvania Coal Co.

Slush from this washery is discharged into a depression from which an old culm bank has been removed, leaving a culm and ash barrier between the slush bank and the Lackawanna River. This deposit extends to the Forest City Colliery, which also discharges slush into it. The Clifford Washery is reworking a number of old culm banks in the vicinity.

Forest City Colliery, Pennsylvania Coal Co.

All sizes of coal larger than stove are prepared dry in the breaker and the smaller sizes in the washery. Slush from this colliery is run to the depression above noted. Waste water, most of it coming from coal pockets under the breaker and dirty in appearance, runs directly to the Lackawanna River.

Clinton Falls Colliery, Clinton Falls Coal Co.

The preparation of all coal is wet, requiring about 37,500 gallons of water per day, taken from Trout Creek, for washing purposes. All waste water and slush, which carry considerable culm, discharge directly to Trout Creek.

East Side Openings, Delaware & Hudson Coal Co.

These openings are on Hudson Creek, about 1,500 feet from its mouth in the Lackawanna River, all coal mined being taken across the river to the Clinton Colliery for preparation. Hudson Creek receives mine water from both openings, washes a considerable quantity of ashes from an adjacent ash bank and a little culm from a nearby culm pile.

Clinton Colliery, Delaware & Hudson Coal Co.

This breaker prepares all the coal by the dry process, the culm from the breaker being dumped to the south on a pile now about 1,600 feet long and very high and wide. Culm from an old bank is prepared in the washery, all slush being flushed to the mines, while the waste water is run to a slush bank draining through an open channel to the Lackawanna River. The wash water supply is pumped from the river.

Richmond No. 4 Shaft, Outlook Coal Co.

This breaker has been removed and all coal mined is taken to the Buffalo Breaker for preparation. One culm bank, in case of a heavy rain and high water, might be washed by a branch of Elk Creek.

Northeast Colliery (Abandoned), Vandling Coal Co.

This breaker stands on the east bank of the Lackawanna River nearly opposite the Northwest Colliery of the Sterrick Creek Coal Company. The fill of the New York, Ontario & Western Railroad prevents any wash from the culm banks to the river.

Northwest Colliery, Sterrick Creek Coal Co.

In the breaker the larger sizes of coal are prepared dry, while the smaller sizes are treated wet in the washery, which obtains its wash water from the Lackawanna River. Connected to the breaker is the washery where the material from a culm bank farther down the river is prepared, as well as the small sizes of fresh mined coal. Slush and waste water are run to a slush bank surrounded by rock, draining to Creek No. 5. The rock and other solid refuse are piled on a rock bank.

Buffalo Breaker, Outlook Coal Co.

In this breaker the large sizes of coal are prepared dry and the smaller sizes wet. At present (May 1914) the breaker is idle, so that the only waste reaching Elk Creek is a stream of clear mine water containing no sediment. In times of high water culm would wash to the creek from the banks which extend directly across the stream.

Storage Yard, Delaware & Hudson Coal Co.

At Simpson, Pa., on the east side of the Lackawanna River, is a storage yard of the Delaware & Hudson Coal Company. The enclosure is about 1,200 feet long and 500 feet wide, at present so nearly full of coal that in times of flood the Lackawanna River would wash away the edges of the coal piles.

Black Diamond Colliery (Abandoned), New York, Ontario & Western Railroad Co.

Opposite Simpson are the old abandoned workings of the Black Diamond Colliery. Culm and rock piles are 800 feet from the river and would scarcely be washed that far, but a stream of mine water from an opening runs to the Lackawanna River.

Tappan Breaker, Archbald Coal Co.

In this small breaker the large sizes of coal are prepared dry and the small sizes wet. Slush and waste water are flushed to a slush bank surrounded by rock which seems to drain to the mines, as no surface outlet nor drainage to the Lackawanna River could be found.

Morss Hill Colliery (Abandoned)

Small rock and culm banks on either side of the highway drain to Elks Creek.

Coal Brook Colliery, Delaware & Hudson Coal Co

The preparation of all coal in this breaker is dry and there is no washery annex. One large culm bank is washed by Coal Brook in times of high water, and mine water from several openings drains to the brook.

Racket Brook Colliery (Abandoned), Delaware & Hudson Coal Co.

All buildings have been torn down, including the breaker and washery. There are some culm banks left, although most of them have been removed.

Murrins Colliery, Fall Brook Coal Co.

The breaker prepares buckwheat and pea coal wet and all larger sizes dry, the washery not being used at present. About 80,000 gallons of mine water are needed per day for washing 100 tons of coal, and all slush and waste water run down the road direct to Fall Brook.

George Giles' Breaker, George Giles, Owner

This is a small breaker, operating only from November 1st to April 1st, and all coal is prepared dry.

Power Plant and Shaft, Delaware & Hudson Coal Co.

On the east bank of the Lackawanna River below Fall Brook, at the Delaware & Hudson Power Plant and Shaft, stands an ash bank subject to direct wash by the river. A stream of mine water is pumped direct to the river.

Drift and Slope, Delaware & Hudson Coal Co.

Streams of mine water enter the river from each of these openings, while at the slope there is a small rock bank and two culm banks subject to wash by the Lackawanna River. There was formerly a breaker here, but now all coal is taken to Powderly No. 2 for preparation.

Thomas Walker Coal Co.

This is a small operation whose average output is but 5 tons per day. There is no washery annex, all coal being prepared dry, while the culm is piled almost anywhere and is washed by Creek No. 9.

South End Coal Co.

This is a small operation, not under the mine laws, working strippings. Preparation is dry, with little culm.

Wachna Breaker, Wachna-Taylor Coal Co.

This operation is small and does not come under the mine laws. All coal is prepared dry, the culm refuse being piled on a bank which is beyond reach of any stream.

Sacandaga Colliery, Sacandaga Coal Co.

This colliery is located on the hill above Carbondale and all coal is prepared wet in the breaker. Slush and waste water run about 200 feet south, where they are turned into a C. I. pipe underground drain, and, as both slush and waste water are untreated, the stream carries much culm. This drain extends south along the Delaware & Hudson tracks and empties into the swamp in which Powder Brook has its source. The average daily output at full capacity is 125 tons. Mine water is pumped to breaker for washing purposes, and the overflow drains with the slush and waste water to the swamp.

Bolands Breaker, Carbondale Mining Co.

The colliery stands on the west side of the swamp in which Powder Brook has its source. Coal is prepared wet in the breaker, using mine water for washing, and the slush is run without settling to the swamp, which is one huge mass of culm. The yearly output of the colliery is about 30,000 tons.

Powderly No. 2 Colliery, Delaware & Hudson Coal Co.

Preparation of all sizes, in both breaker and washery, is wet. Wash water is pumped from the mines. Culm from a large bank is prepared in washery, which also prepares small sizes of coal from the breaker. Slush from the washery is run back to a slush bank, enclosed by a large culm pile, the waste water from which drains to Powder Brook. Below the colliery a large quantity of mine water, which contains some culm, is pumped to Powder Brook. Waste water runs direct to brook from breaker, although at times it is flushed to the mines.

Erie Colliery, Pennsylvania Coal Co.

Preparation is both wet and dry, all wash water being pumped from the mines. Slush water is flushed direct to the mines, while the excess mine and waste water run direct to Powder Brook.

Stone's Mines, Stone Coal Co.

This is a small concern not under the mine laws. All preparation is dry and there is no drainage. At the time of inspection it was not working.

Keystone Colliery, Sullivan & Schraeger

Preparation of fresh mined coal is both wet and dry, and in addition the company is washing in culm from a large bank and preparing it in the breaker. A small stream of waste water runs direct to Aylesworths Creek, carrying some fine culm and washing more from a large culm bank nearby.

West Mountain Coal Co.

All sizes are prepared dry and there is no drainage from the breaker. At the present time all waste culm is banked.

Fireside Coal Co., Brown & Sons, Owners

All sizes are prepared wet, and the waste water flows from the breaker through culm to Rush Brook, carrying dirt and culm and thereby polluting the stream. About 10,000 gallons of water per day are used.

Jermyn Colliery, Delaware & Hudson Coal Co.

The larger sizes are prepared dry in the breaker, and the small sizes in the washery, which uses Lackawanna River water for washing. Slush is usually flushed to the mines, although a bank has been provided in case the line becomes blocked. The waste water, very black and heavy with culm, runs by an open channel to the Lackawanna River. Mine water is pumped from several openings both to Rush Brook and to the Lackawanna River.

Opening, Delaware & Hudson Coal Co.

Mine water is pumped direct to the Lackawanna River from this drift.

Eaton Shaft, Scranton Coal Co.

The breaker and washery have been removed. All coal mined here is carried to the Raymond Colliery (Scranton Coal Company) for preparation. There is no perceptible wash nor drainage from the shaft or waste banks.

Binghamton Colliery, Archbald Coal Co.

The preparation of the large sizes of coal is dry and the smaller ones wet, both mine and surface water being used for washing principally the former. Slush and waste water run to a rock bank enclosure faced with ashes, the dirty effluent carrying fine culm to White Oak Run.

White Oak Openings, Delaware & Hudson Coal Co.

The breaker is removed, and all coal mined here is taken to Gravity Slope Colliery for preparation. Several very large culm banks remain, one of which is washed for some distance by White Oak Run. Mine water is pumped direct to the Lackawanna River, and a small stream from an old opening runs into White Oak Run.

Gravity Slope Colliery, Delaware & Hudson Coal Co.

All preparation in this colliery is wet, wash water being pumped from a dam in the Lackawanna River. The slush is pumped to a slush bank, which, however, is not very efficient, as the effluent draining to the Lackawanna River is full of culm. Waste water is run direct to the river, and this, too, contains considerable fine culm. Several culm deposits occur in the river just below this colliery, although the current is swift.

Sunnyside Colliery, Humbert Coal Co.

Preparation of coal in the breaker is wet, the water for washing being pumped from a dam in Grassy Island Creek to a reservoir on the hill above the breaker. All slush from the breaker is run to a small slush bank opposite, the drainage from which, with the waste water, is discharged into Grassy Island Creek. Two large rock and culm banks are washed at the foot by the creek. About 150,000 tons of coal per year are recovered from the culm bank.

Dolph Breaker, Dolph Coal Co.

At present the colliery has been closed down, as the principal workings are flooded and the mine may have to be abandoned. When last working the preparation of coal was both wet and dry, mine water composing the principal supply for washing coal. Slush was run to a slush bank draining to Grassy Island Creek.

Mt. Jessup Colliery, Mt. Jessup Coal Co.

Wet preparation is used in both breaker and washery, all wash water being pumped from the Lackawanna River. Waste water from the breaker drains direct to the creek, while the slush from the washery runs first to a slush bank and then drains to Grassy Island Creek.

North American Washery, North American Coal Co.

Approximately 540,000 gallons of water per 9-hour day are pumped for washing purposes from the Lackawanna River. The slush runs to a settling bank draining into Grassy Island Creek near its mouth.

Sterrick Creek Colliery, Sterrick Creek Coal Co.

Preparation in the breaker is wet, all wash water being pumped from the mines. A portion of the slush is flushed into the mines, but some of it escapes and runs to Grassy Island Creek. The Lackawanna River receives direct all waste water besides washing the foot of three large rock and culm banks.

Riverside Colliery, Scranton Coal Co.

Preparation of coal in the breaker is both wet and dry, egg and stove sizes being jigged, while buckwheat is treated dry. Slush water is carried by an open drain into Creek No. 19; the water is very black and full of culm. Two huge culm banks are located near this colliery, both of which drain to Creek No. 19, but are not washed by it.

Peck's Shaft, Mt. Jessup Coal Co.

Mine water is used on all coal in the colliery, after which it is rewashed in loading. Slush is run to a slush bank, which is situated right by the Lackawanna River, and drains directly into it. The waste water, which is nearly as great in volume as the slush, is run direct to the Lackawanna River without any treatment, and carries some culm with it.

Electric Co.

A bank, which was formerly a portion of the fill for the Delaware & Hudson Coal Company's Gravity Road, has been bought by the Electric Company, who are hauling it away dry and using it for boiler fuel.

Raymond Colliery, Scranton Coal Co.

This plant prepares No. 1, No. 2 and No. 3 buckwheat wet, and all other sizes dry. The washery is used as a breaker annex, requiring for washing approximately 157,500 gallons of water per day. Wild Cat Creek washes the culm banks and receives all waste water and drainage from the slush bank.

Ontario Colliery, Scranton Coal Co.

In the annex all sizes of coal smaller than egg are prepared wet, part of the egg is wet and part dry, and all sizes above egg are dry in the breaker. From 500 to 600 tons of coal a day are washed, using approximately 144,000 gallons of water. The untreated slush is discharged into Tinklepaugh Creek, which also washes the edge of the culm banks.

Grassy Shaft, Delaware & Hudson Coal Co.

On the site of the old Grassy Island Colliery a large culm bank situated at a bend in the Lackawanna River, is washed directly by this stream. About 1,500 feet up the hill, nearly midway between Sterrick and Eddy creeks, is Grassy Shaft (Delaware & Hudson Coal Co.), from which, however, there is no drainage.

Lackawanna Colliery, Sterrick Creek Coal Co.

Preparation of all coal is wet, both in the washery annex and in the breaker. The washery slush is flushed to the mines through a borehole, although the waste water from the breaker drains to Creek No. 22, discoloring it badly.

Olyphant Colliery No. 1, Delaware & Hudson Coal Co.

The preparation in the breaker is dry, but the washery prepares the smaller coal from the breaker wet, besides washing culm from banks nearby. Slush is usually flushed into the mines, although when the pumps or slush line block up a slush bank draining to the Lackawanna River is utilized. The company employs a man to shovel culm out of the waste water stream which flows direct from the washery to the river otherwise untreated.

Marshwood Colliery, Moosic Mountain Coal Co.

The breaker has been removed and merely a shaft is now working. All coal mined is shipped in cars to Jessup for preparation.

Carney & Brown Coal Co.

All coal is prepared dry. No mine water is pumped out, as it all drains to another company's workings inside.

Underwood Colliery, Pennsylvania Coal Co.

This new steel structure, a combined washery and breaker, is not yet completed (May 1914). The water supply for the washery is obtained from a dam on the main branch of Eddy Creek and also from the mines. Below the colliery a rock bank extends across the swamp, into which waste water and slush will be run. A dam is under construction above this bank which will retain part of the water from the washery so that it can be pumped back and reused. In order to reach Eddy Creek the waste water will have to overflow the dam and seep through the rock bank. The company expect to have too little rather than too much water.

Eddy Creek Breaker, Delaware & Hudson Coal Co.

Preparation is entirely dry. The drip from the engine house is the only water draining to the Lackawanna River, although from several of the culm and rock banks sediment is washed into it.

Johnson Colliery No. 2, Scranton Coal Co.

In the breaker everything above buckwheat is prepared dry, while sizes under that are prepared with mine water in the washery. Slush is flushed to the mines and mine water runs direct to Price Creek, the only refuse going to outside banks being the mine rock.

Pancoast Colliery, Price-Pancoast Coal Co.

The preparation in the breaker is dry for all sizes of coal. All the mine water, and a little waste water from loading cars, drains along a culm bank to Creek No. 26.

Storrs Colliery, Delaware, Lackawanna & Western Coal Co.

The breaker prepares all coal above buckwheat dry, while sizes from buckwheat down are prepared in the washery. The slush is run to the Scranton Anthracite Brickette Plant, where it goes into a settling machine. A portion of the slush not needed at the brickette plant, and all waste water, drain direct to Smith Creek.

Brickette Works, Scranton Anthracite Brickette Co.

Part of the slush from the Storrs Colliery is run to a settling machine, which removes the culm. This fine material is mixed with pitch and tar, and then pressed into different sizes in a bricketting machine. The waste water drains direct to Smith Creek, which is dirty and full of culm all the way to its mouth in the Lackawanna River.

Richmond No. 3, Scranton Coal Co.

All sizes are prepared dry, the culm being placed on a bank which the Scranton Traction Company is removing for fuel.

Marvine No. 1, Delaware & Hudson Coal Co.

The breaker prepares all sizes from birds-eye up by a dry process, though the washery used as a breaker annex turns out birds-eye wet, using mine water for washing. All slush is flushed to the mines, and the waste water runs to the Lackawanna River.

Marvine No. 2, Delaware & Hudson Coal Co.

The new breaker across the Lackawanna River from Marvine No. 1 is nearly completed, although the new washery next to the breaker is still under construction. The culm bank alongside the washery is subject to wash by the Lackawanna River.

Cayuga Colliery, Delaware, Lackawanna & Western Coal Co.

All sizes from buckwheat down to No. 2 barley are prepared wet in the washery annex, and the others dry in the breaker. Mine water is used for washing purposes and averages approximately 420,000 gallons a day. Waste water drains to Leggitts Creek, but all slush is flushed to the mines.

Leggitts Creek Colliery, Delaware & Hudson Coal Co.

Preparation is both wet and dry with the washery as a breaker annex. Slush runs to the mines and waste water drains to Leggitts Creek, which stream furnishes the wash water supply.

Von Storch Colliery, Delaware & Hudson Coal Co.

Preparation of coal in the breaker and washery is both wet and dry, all wash water being pumped from the Lackawanna River. Slush water from the washery as well as from thhe breaker is run through boreholes to the mines, while the mine water is pumped direct to the Lackawanna River.

Clearview Colliery, Peoples Coal Co.

All sizes are prepared dry, and there is no drainage from the breaker.

West Ridge Colliery, Scranton Coal Co.

The preparation of all coal is dry. As the breaker is in the heart of Scranton there is no room for waste banks, so the culm is shipped away in cars. No mine water is pumped here, as it drains inside to another mine.

Brisbin Colliery, Delaware, Lackawanna & Western Coal Co.

In the washery all sizes from buckwheat down are prepared wet, and in the breaker the larger sizes dry. During one month 19,790 tons of coal were prepared wet, the slush and waste water all running into the mines.

Bulls Head Colliery, Bulls Head Coal Co.

Preparation of all coal is dry, and no mine water is pumped to the surface.

No. 1 Plane Colliery, Pennsylvania Coal Co.

The larger sizes of coal are prepared dry in the breaker and the smaller ones wet in the washery, but no culm from the banks is prepared at present. Mine water, which is stored in the pond, is used for washing. All waste water is pumped to a slush bank, the effluent from which is not very dirty, but numerous culm deposits are found in Creek No. 29, to which it drains.

Manville Shaft Colliery, Delaware & Hudson Coal Co., Delaware, Lackawanna & Western Coal Co., Joint Owners

Preparation of coal is both wet and dry, although the only water which reaches the creek is that used to flush out ashes. Both waste water and slush are flushed to the mines.

Economy Washery, Economy Light, Heat & Power Co.

A large culm bank near the bend in the Lackawanna River is being prepared in this washery, the wash water being pumped from the river. The slush is run direct to the river without any treatment whatever, and carries with it a large quantity of culm.

No. 5 Colliery, Pennsylvania Coal Co.

In the breaker mine water is used in washing all sizes of coal smaller than chestnut, while the larger sizes are prepared dry. All slush and waste water are flushed to the mines, and there is no surface drainage from the breaker.

Green Ridge Breaker, Green Ridge Coal Co.

Preparation is dry for all sizes, and no water whatever is used in the breaker nor pumped out at the shaft.

Pine Brook Colliery, Scranton Coal Co.

This breaker prepares dry all sizes larger than chestnut, while coal from chestnut down is prepared wet. At present the washery is only handling small coal from the breaker but later is expected to wash culm from the bank. All wash water is pumped from the mines, and all slush is returned to the old workings. No drainage was found from either the breaker or washery to the Lackawanna River. One culm bank is washed by the river.

Diamond Colliery, Delaware, Lackawanna & Western Coal Co.

In the washery, which uses mine water for washing purposes, the smaller sizes are prepared wet, and in the breaker the larger sizes dry. About 336,000 gallons of wash water are used each day, supposedly all flushed back to the mines as slush. However, some silt and culm flows with the excess mine water to the Lackawanna River.

Mt. Pleasant Colliery, Scranton Coal Co.

Mine water is used to prepare No. 1, No. 2 and No. 3 buckwheat in the washery annex, and the other sizes are treated dry in the breaker. Slush runs to a settling bank from which there is no surface draining.

John J. Boland Coal Co.

This operation is a very small one, its preparation of coal is all dry, and there is no drainage of waste or mine water.

Depew Coal Co.

All preparation is dry, as this is a very small operation, consisting of one drift and a small breaker. Coal is sold retail at the breaker.

Spencer Colliery, A. D. & F. M. Spencer Coal Co.

The breaker prepares the larger sizes of fresh mined coal dry, while the washery treats the smaller sizes wet, and also rewashes some culm from a bank. Wash water is pumped from Roaring Brook, at an average rate of 450 gallons per minute, for 8½ hours per day. Slush is run to a slush bank which drains to the brook.

Nay Aug Colliery, Nay Aug Coal Co.

All preparation is wet, both in the breaker and washery, although at present the washery is only preparing smaller sizes from the breaker and not reworking any banks. Wash water is pumped from Roaring Brook and the slush runs to a bank draining back to the same stream.

No. 6 Colliery, No. 6 Coal Co.

A smaller breaker prepares dry all coal from one drift, so that no water is used nor pumped at this operation.

Oxford Breaker, Peoples Coal Co.

Mine water is pumped to wash all sizes of coal up to chestnut, while all sizes above that are prepared dry. All slush and waste water run direct to the mines, and there is no surface drainage from the breaker. Culm banks have been untouched for ten years, as all rock is now crushed and flushed inside, while the banks are too far removed from any stream for erosion.

Bellevue Colliery, Delaware, Lackawanna & Western Coal Co.

In the breaker all coal is prepared wet, mine water being used. A small stream of mine water, the overflow from the breaker supply, runs direct to the Lackawanna River. Slush is passed over a 3/64 inch screen and flushed direct to the mines, although the drip from the slush pumps runs with the mine water to the river. The washery was idle at the time of inspection.

Dodge Colliery, Delaware, Lackawanna & Western Coal Co.

All coal is prepared wet with wash water pumped from the mines. Slush runs to a slush bank under which is said to be a mine fire that the company desires to put out. The waste water passes through the bank, under the Central Railroad of New Jersey tracks, into the Lackawanna River. When mine fire has been extinguished, slush will be run to the mines.

Bradley's Washery No. 2, South Side Coal Co.

At present the washery is idle, but when in operation the slush runs to a slush bank, the effluent from which drains to the Lackawanna River. All wash water is pumped from the river.

Bradley's Washery No. 1, South Side Coal Co.

This washery stands across the Delaware & Hudson Railroad tracks from the National Mines. All wash water is pumped from the Lackawanna River. The slush from the washery runs to a bank and drains to river, the effluent carrying considerable culm.

National Mines, Delaware, Lackawanna & Western Coal Co.

All sizes of coal up to pea are prepared wet in the washery, and above pea coal the process in the breaker is dry. The washery pumps mine water for washing purposes, and discharges the slush through a borehole to the mines. Waste water flows direct to the Lackawanna River, forming quite a large stream which is dirty and full of culm.

Capouse Colliery, Scranton Coal Co.

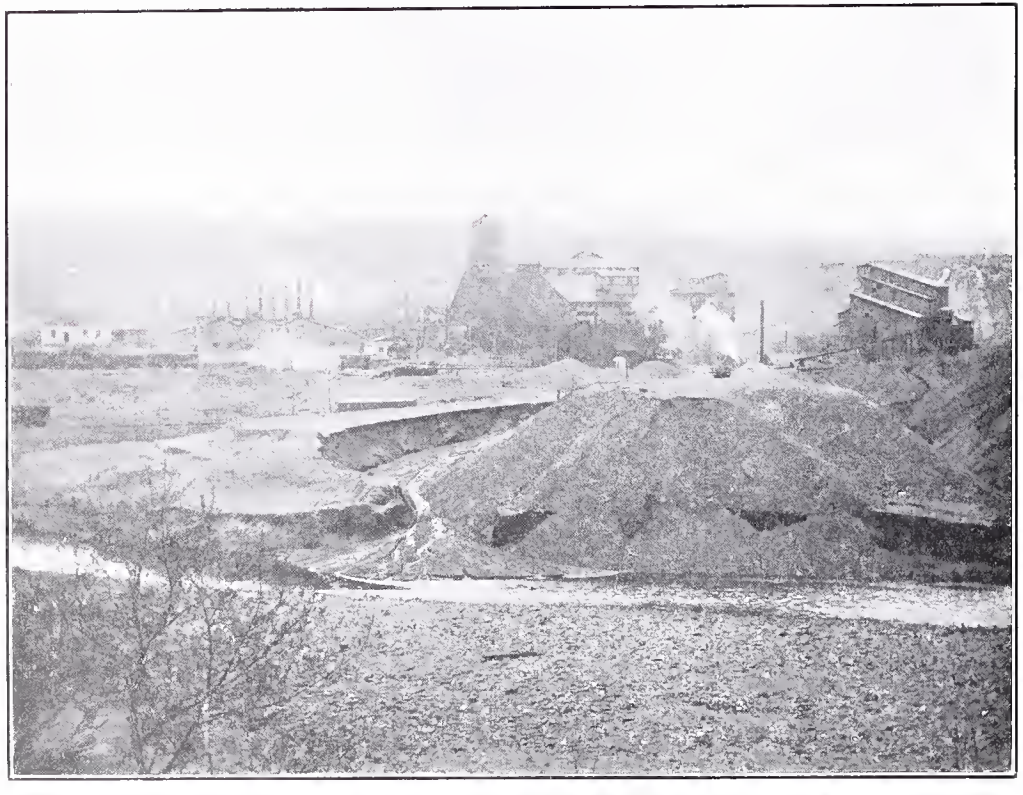
Washery annex prepares No. 2 and No. 3 buckwheat wet, and the rest of the coal is treated dry in the breaker. Slush runs to a slush bank well enclosed by ashes, through which the waste water must drain before reaching Keyser Creek. The small culm deposits in the creek have more likely been washed down from the banks rather than carried in by waste water.

Hyde Park Colliery, Delaware, Lackawanna & Western Coal Co.

Preparation of all sizes above buckwheat is dry in breaker, and from buckwheat down is wet in the washery annex. The slush from washery is supposedly all flushed to the mines, but an overflow stream, carrying a small per cent of culm, drains to Keyser Creek.

Hampton Washery, Delaware, Lackawanna & Western Coal Co.

All preparation is wet. Part of the slush is flushed to the mines, part of it runs to a slush bank, and the balance drains direct to the creek. It was not working at time of inspection, but from all indications considerable culm reaches Keyser Creek at this point.



Bradley's Washery No. 1 discharging Slush into Lackawanna River

Sloan Breaker, Delaware, Lackawanna & Western Coal Co.

All preparation is dry and there is no surface drainage from the breaker.

Continental Breaker, Delaware, Lackawanna & Western Coal Co.

All preparation in this breaker is dry, so that there is no waste drainage to Keyser Creek, nor is any mine water pumped out of the workings.

Archbald Colliery, Delaware, Lackawanna & Western Coal Co.

Sizes of coal from No. 2 barley to buckwheat are prepared wet in the washery annex, while the preparation of the rest is dry in the breaker. Part of the slush is flushed to the mines and the remainder runs to a slush bank. This latter has evidently broken in the past, causing quite a lot of culm deposition along Keyser Creek.

Holden Colliery, Delaware, Lackawanna & Western Coal Co.

The washery annex prepares wet all sizes from pea coal down, whereas the breaker treats the larger sizes dry. All slush is flushed to the mines, while the mine water and a small stream of waste water from the breaker drain to Keyser Creek.

Marion Colliery, Marion Coal Co.

Owing to a dispute about the ownership, this colliery has not been in operation since 1912. (Boland-Archbald Case.)

Taylor Colliery, Delaware, Lackawanna & Western Coal Co.

In the breaker, coal from pea to No. 2 barley is prepared wet, and all other sizes dry, while in the washery all coal is wet from pea coal down. Slush from the washery is flushed to the mines, although within a few weeks it is expected to run it to a waste bank. Some waste water from the breaker and mine water are run direct to Keyser Creek.

Washery, Thorne Neale Washery Co.

This washery, which stands at a bend in the river above Greenwood No. 1 Shaft (Delaware & Hudson Coal Company), runs its slush to a bank that drains to the Lackawanna River. The effluent from the bank percolates through about four feet of culm before reaching the discharge chute.

New Breaker, Minooka Coal Co.

This company has one new opening recently started, but as yet no rock nor culm banks have accumulated.

Premier Washery, Premier Coal Co.

This washery will be abandoned very soon, as the culm bank is about washed out. Wash water is pumped from Spring Brook, and after being used the slush and waste water are run to a bank which drains to Creek No. 32.

Greenwood No. 2 Colliery, Delaware & Hudson Coal Co.

The breaker prepares the larger sizes of coal dry and the washery the smaller sizes wet, using mine water for washing purposes. Slush from the washery goes to a bank draining to the river, the effluent being dirty and full of culm, while the waste water runs untreated to the Lackawanna River.

Consolidated Colliery, Pennsylvania Coal Co.

Large sizes of coal are prepared dry in the breaker and the smaller ones wet in the washery, using mine water for washing. Slush runs to a bank which drains to Spring Brook.

Old Forge Colliery, Pennsylvania Coal Co.

The large sizes of coal are prepared dry in the breaker and the smaller ones wet in the washery. From No. 13 Shaft (Pennsylvania Coal Company) mine water is pumped to a concrete reservoir thence to Old Forge Washery, the overflow from the reservoir going direct to the Lackawanna River. All waste water and slush are flushed to the mines, although a slush bank is ready for emergencies. The rock and culm piles at the colliery and at No. 1 Shaft are too far removed from the river to be washed by it. Near Shaft No. 2 a rock and ash bank are on the west bank and are washed by the Lackawanna River.

Jim Dainty's Opening

One small opening, where the coal is broken by hand and shoveled on a screen, is the extent of this operation. Some of the coal is washed by water pumped from the creek with a hand pump.

Charles P. Holden's Breaker

The output of this operation averages 50 tons a day which is prepared dry. The only water required is for the boilers, so that the creek receives no culm from this colliery.

Heidelburg No. 1 Colliery, Lehigh Valley Coal Co.

The breaker prepares the larger sizes dry, while the smaller sizes are prepared in the washery, mine water from a storage tank on the hill being used. The washery slush runs to a bank, and the effluent drains with the other waste water to Creek No. 34.

Washery, United Coal Co.

A washery near the former site of the Hillside Colliery (Pennsylvania Coal Company) is washing and breaking up a rock bank. No slush nor waste water was found reaching Creek No. 34 from this operation.

Washery, Pennsylvania Coal Co.

Culm from a large bank near the Langcliffe Colliery is being conveyed across Creek No. 34 by means of a scraper line to the Pennsylvania Coal Company Washery. Water from the creek is used for washing, while the slush is discharged on the ground and most of it goes back into Creek No. 34.

Langcliffe Colliery, Delaware & Hudson Coal Co.

The preparation for the larger sizes is dry in the breaker, and wet for the smaller sizes in the washery, which uses mine water for the purpose. Slush runs to a small bank draining to Creek No. 34.

Central Colliery, Pennsylvania Coal Co.

The larger sizes of coal are prepared dry in the breaker, and the smaller sizes wet in the washery, which obtains its wash water from the mines. The slush runs to the mines through a borehole and the waste water direct to Creek No. 34.

Pyne Colliery, Delaware, Lackawanna & Western Coal Co.

In the breaker, sizes of coal from pea up are prepared dry, and in the washery, those smaller than pea, all rock and slush being first pulverized and then flushed to the mines. Pyne Creek receives a stream of mine water, the wash water overflow, and washes some of the culm banks.

Sibley Colliery, Pennsylvania Coal Co.

The washery annex prepares the smaller sizes wet, while the breaker prepares the coal larger than chestnut dry. Waste water and slush run to a bank within a rock bank enclosure, which is so well built up that the waste water can only reach the stream by seeping through a rock pile. St. Johns Creek receives the excess mine water and later washes in culm and sediment from the adjacent banks.

Jermyn No. 1, Jermyn Coal Co.

All sizes above barley are washed in the breaker, while the washery prepares barley and rice. The slush runs to a waste bank and drains thence direct to St. Johns Creek. About 200,000 tons of coal are washed per year, mine water being used. St. Johns Creek flows along the edge of the rock banks and washes down sediment from them.

William A. Colliery, Lehigh Valley Coal Co.

In the breaker the larger sizes are prepared dry, and in the washery annex the small sizes are washed with mine water. Slush and waste water are run to a bank, partly enclosed by rock. There is, however, an opening 300 feet wide through which culm and waste water are at present draining to Coal Brook. This is being filled up and in a month (June 1914) should be entirely enclosed by rock. Mine water runs both to Coal Brook and to the Lackawanna River, while some breaker waste water drains to Coal Brook.

Hallstead Colliery, Delaware, Lackawanna & Western Coal Co.

All sizes from pea coal down are prepared wet in the washery, and larger sizes dry in the breaker. Waste water from the breaker and washery drain direct to the Lackawanna River. Washery slush is pumped to a bank, from which there is no apparent outlet, company officials claiming that the water sinks into the mines.

Barnum Colliery, Pennsylvania Coal Co.

All sizes above buckwheat are treated dry in the breaker, the smaller ones being prepared wet in the washery. A conveyor removes culm from a bank to cars which carry it to No. 7 Colliery for preparation, but no water is used in this operation. An open channel from the breaker and washery leads direct to Lackawanna River. At present most of the waste water and slush is being pumped to a bank on the hill, which drains to an open channel joining the waste water from No. 9 Breaker and emptying into the Susquehanna River.

Schooley Shaft, Pennsylvania Coal Co.

This new shaft is just being driven, and when completed the coal will be taken underground to the Ewing Colliery on the opposite side of the Susquehanna River. Mine water averaging 4,000 gallons a minute for 24 hours a day are pumped from old workings of the Schooley Mine and run to Carpenters Creek. A sewer is under construction which will carry this mine water direct to the Susquehanna River.

Exeter Colliery, Lehigh Valley Coal Co.

Coal larger than chestnut is prepared dry in the breaker, and the smaller sizes wet in the washery, using about 800 gallons of mine water per minute. All waste water, drainage from the ash pit and slush runs to the mines, while the excess mine water flows through an open ditch to Carpenters Creek.

Stevens Colliery, Lehigh Valley Coal Co.

This breaker is abandoned and the washery is preparing only enough fuel from a culm bank to supply the boiler room. All coal mined is loaded in cars and taken to the William A. Colliery for preparation, while the mine water, drainage from the slush bank and water used to cool ashes run to Carpenters Creek.

J. P. Cake Breaker (Abandoned), J. P. Cake, Supt.

This breaker and washery are still standing, although abandoned in 1910. The culm banks are too far removed to drain either to Carpenters Creek or the Susquehanna River.

Seneca Colliery, Lehigh Valley Coal Co.

All sizes above egg are prepared dry and the smaller sizes wet, requiring about 600 gallons of mine water per minute for washing. All waste water and slush are flushed to the mines, while the excess mine water is discharged behind the culm bank and seeps through it to the Susquehanna River. A large culm and rock bank extends along the edge of the river to the bend above the upper Pittston bridge, and is washed by the stream even at low water.

No. 9 Colliery, Pennsylvania Coal Co.

All sizes larger than pea coal are prepared dry in the breaker, and sizes smaller than pea wet in the washery, using approximately 1,100 gallons of mine water per minute. Slush from the washery is pumped to a bank about 2,000 feet long, draining to Mill Brook, though part of the slush may be flushed to the mines when conditions are favorable inside. Excess mine and waste water run to an open channel and carry considerable culm into the Susquehanna River.

Heidelburg No. 2 Shaft, Lehigh Valley Coal Co.

The coal mined at this shaft is shipped to Heidelburg No. 1 Colliery for preparation, while the mine water runs to a pond near the Butler Colliery along the Laurel Line tracks.

Butler Colliery, Pennsylvania Coal Co.

Sizes of coal larger than egg are prepared dry in the breaker, while in the annex the smaller sizes are prepared wet, requiring about 500 gallons per minute for washing. No mine water is pumped out at the Butler openings, but mine water from Heidelburg No. 2 furnishes the wash water supply. Slush is run to a bank which drains to an underground channel near North Pittston station on the Laurel Line, and thence to the Susquehanna River.

Yost Colliery, Yost Mining Co.

Although the buildings are intact, this colliery has been shut down for the past two years. Tompkins Creek, which flows by, receives mine water from the Yost workings and washes the edges of a rock bank.

No. 6 Colliery, Pennsylvania Coal Co.

Sizes of coal larger than pea are prepared dry in the breaker, while in the washery annex mine water is used to wash sizes from pea to barley. All slush and waste water is flushed to the mines, while the mine water runs through the culm banks and drains to Creek No. 42.

Ewing Colliery, Pennsylvania Coal Co.

The breaker operates dry, and the washery is preparing the small sizes from the breaker, reworking a nearby culm bank, and washing culm brought in cars. For washing purposes, fresh water from the left branch of Creek No. 42 and mine water from No. 4 and No. 7 shafts are used. The company claims to flush all slush to the mines, but the waste water which discharges into Creek No. 42 by means of an underground tunnel is filled with culm, while at the mouth of the creek there is a large culm deposit in the Susquehanna River.

Colliery No. 14, Pennsylvania Coal Co.

The breaker prepares the larger coal dry and the washery annex treats the smaller sizes wet, using mine water for washing. All slush and waste water run direct to the Susquehanna River by an underground culvert, a very large quantity of culm going with it. The waste banks around this colliery are not subject to direct wash by any stream.

Troy Breaker, Rissinger Bros. & Co.

All coal is prepared wet in the breaker, using both mine and spring water for an average daily output of 200 tons. All slush runs to a bank draining to a sump, which also receives the excess mine water. The overflow, black and carrying fine culm, goes through an open channel to Abrams Creek.

Mt. Lookout Colliery, Sterrick Creek Coal Co.

All sizes of coal from chestnut up are prepared dry in the breaker, and from chestnut to barley wet in the annex, using about 500 gallons of mine water per minute. The slush, waste water and the drainage from the ash pit are flushed to the mines, while the excess mine water drains to Abrams Creek.

Westmoreland Colliery, Lehigh Valley Coal Co.

The breaker ships all coal larger than stove dry, while the smaller sizes, averaging about 300 tons a day, are washed in the annex. Slush and waste water are either flushed to the mines or to a bank draining to Abrams Creek. When the crusher contemplated has been installed, all mine rock and breaker refuse will be sent to old mine workings with the slush, so that the excess mine water will be the only refuse reaching Abrams Creek.

Maltby Colliery, Lehigh Valley Coal Co.

About 500 gallons of mine water per minute are used to prepare all sizes of coal smaller than egg, the larger ones being dry. By means of a borehole, the slush, waste water and ash pit drainage are run into the mines, although the surface and excess mine water drain direct to Abrams Creek.

Forty Fort Colliery, Sterrick Creek Coal Co.

The average daily output of wet coal, including all sizes up to stove, is 700 tons, which requires 500 gallons of mine water per minute for washing purposes. Usually the waste water, ash pit drainage and slush is flushed to the mines, although a slush bank draining to Abrams Creek is used when the borehole is clogged or unable to handle the entire quantity.

Boston Colliery, Pennsylvania Coal Co.

The breaker is dismantled and all coal mined here is taken to the Ewing Colliery for preparation. Mine water from an old opening drains to the East Branch of Gardners Creek.

Pickaway Colliery, McCauley Coal Co.

The preparation of all coal is wet, and the slush and waste water are run to a flat where part of the culm is deposited, although most of it eventually reaches Lamp Black Creek.

Laflin Colliery, Delaware & Hudson Coal Co.

The small sizes of coal are prepared in the wet side of the breaker, and the larger sizes in the dry side. All mine water not used for washing purposes drains to Gardners Creek, while the slush and waste water are flushed to the mines.

Keystone or Ridgewood Colliery, Traders' Coal Co.

All coal is prepared wet, the slush and waste water being run direct to Paddens Creek and carrying a large amount of culm in suspension. Culm banks are washed by the creek, which thus gathers more culm.

Central Colliery, Central Coal Co.

All coal is prepared wet in the breaker with water pumped from Gardners Creek. The slush is run to a flat near the banks of Mill Creek, much of the culm flowing into the stream.

Delaware Colliery, Delaware & Hudson Coal Co.

The preparation in the breaker is dry, except for buckwheat and birds-eye which are wet. All slush and waste water are flushed to the mines, while the excess mine water is pumped to Mill Creek just below the breaker. The washery has not been in use for some time.

Madeira Colliery, Wilkes-Barre Colliery Co.

In the wet side of the breaker all sizes of coal smaller than pea are prepared with mine water, while sizes larger than pea are prepared in the dry side. The slush and waste water are flushed to the mines.

Pine Ridge Colliery, Delaware & Hudson Coal Co.

The breaker preparation is dry, while the washery prepares the smaller sizes wet, using mine water for washing purposes. All solid refuse, culm and rock is crushed up and flushed to the mines with the washery slush. The waste and excess mine water run to a small creek, leaving numerous culm deposits on the banks and later emptying into Mill Creek.

Miners Mills, Miners Mills Coal Co.

All preparation in this breaker is dry and there is no mine water brought to the surface.

Openings, Lehigh Valley Coal Co.

At Mountain Park, the Lehigh Valley Coal Company have some openings from which mine water enters Laurel Run. The coal mined here is prepared at the Mineral Spring Colliery.

Laurel Shaft and Washery, Delaware & Hudson Coal Co.

This breaker has been removed so that nothing is left but a slope, a shaft, and a small washery, which washes enough culm to supply the boilers. The only possibility of pollution to Laurel Run is by washing the edges of culm banks.

Mineral Springs Colliery, Lehigh Valley Coal Co.

In this breaker all coal is prepared wet. The solid waste, both culm and rock, is run through a pulverizer and flushed with the slush and waste water to the mines, so that nothing reaches Laurel Run. This is considered one of the most up-to-date collieries in the anthracite region.

Baltimore No. 5, Delaware & Hudson Coal Co.

The preparation in the breaker is dry, with a washery annex for the smaller sizes, where mine water is used for washing purposes. Slush runs to a settling tank and the waste water from the tank goes into a reservoir and is used again. All culm remaining in the tank is shoveled to a pile on the ground, where it is subject to wash by an overflow pipe from the reservoir, which drains to Laurel Run. In case the settling tank becomes blocked, a slush bank is utilized, which, with two other dirty waste water streams, drains direct to Laurel Run.

No. 3 Baltimore (Abandoned), Delaware & Hudson Coal Co.

The colliery is abandoned and nothing remains but a few culm banks. A stream of water flows from under the rock bank, and although its source was not located it appears to be a surface stream draining the surrounding territory.

No. 2 Shaft, Delaware & Hudson Coal Co.

Two pumps are used to pump mine water to the West Branch of Laurel Creek, but these are not working at the present time (May 1914).

Prospect Colliery, Lehigh Valley Coal Co.

The breaker is "dry," while the washery prepares the smaller sizes of coal with wash water pumped from the Susquehanna River. Waste water runs to a settling tank draining to the Susquehanna River and the washery slush to a slush bank discharging into Mill Creek. The stage of water in the river at the time of examination prevented a determination of the extent of the culm deposits in and along the stream.

Samuel Chase Washery

This washery was not working at the time of inspection and shows evidence of having been abandoned.

Washery, Wilkes-Barre Electric Light Co.

This small operation just below the Prospect Colliery is washing merely enough culm to supply the boilers at the power plant. All of the slush and the waste water appear to run into the city sewers, thence to the Susquehanna River.

Dorrance Colliery, Lehigh Valley Coal Co.

The preparation in the breaker is dry, and all waste rock and culm from the breaker are flushed into the mines. A small stream of mine water runs to the Susquehanna River.

Baltimore Tunnel Colliery, Delaware & Hudson Coal Co.

The breaker prepares all coal wet, using mine water from a reservoir which supplies both breaker and washery. From a bank back of the colliery the washery is preparing coal for use in the boilers. Rock is crushed and run with the slush to the mines, while the waste water reaches the Susquehanna River through the Wilkes-Barre city sewer.

Hillman Vein Colliery, Wilkes-Barre Anthracite Coal Co.

The breaker is preparing all coal by the wet process, using mine water, and all rock is crushed up and flushed with the slush and ashes to old workings in the mines. What little waste water runs from the breaker drains to the city sewer. The washery has not been worked for a year and may be abandoned.

Hollenback No. 2, Lehigh & Wilkes-Barre Coal Co.

Dry preparation takes place in the breaker for the larger sizes, and the washery treats the small sizes by the use of mine water from a supply reservoir. All slush and waste water are flushed to the mines, while the mine water overflow reaches the city sewers.

South Wilkes-Barre Colliery, Lehigh & Wilkes-Barre Coal Co.

In the breaker the large sizes are prepared dry and in the washery the smaller sizes wet, mine water being used for washing purposes. Slush and part of the waste water are flushed into the mines, though some culm bearing water drains into the Pennsylvania sewer.

Harry E. Colliery, Sterrick Creek Coal Co.

About 700 tons of coal a day are prepared wet, using from 500 to 600 gallons of mine water per minute for washing. The slush runs to an ash lined slush bank, which drains with the excess mine and surface water to the East Branch of Toby Creek, while the waste water and ash pit drainage is flushed to the mines.

Pettebone Shaft, Delaware, Lackawanna & Western Coal Co.

This breaker has been idle since 1911, and all coal mined is prepared at the Woodward Colliery. Mine water and culm washed from the bank are discharged into the East Branch of Toby Creek at this point.

Louise Colliery, Raub Coal Co.

In the breaker all coal larger than egg is prepared dry, while about 400 tons a day of the smaller sizes are washed with water pumped from Toby Creek, requiring about 300 gallons per minute. The slush and waste water are flushed to the mines, but the mine water, which is dirty and carries some fine silt, is troughed to Toby Creek below the Black Diamond Colliery.

East Boston No. 2 Washery, East Boston Coal Co.

About 65 tons a day are prepared with water pumped from Toby Creek. Part of the slush is piped to a borehole which enters the East Boston Mines, but the remainder of the slush with all waste water runs to a small slush bank on the edge of Toby Creek. At present the slush bank is breached so that little or no settling takes place and the culm washes into the creek bed.

Black Diamond, Plymouth Coal Co.

The breaker prepares all coal dry except about 50 tons of rice coal per day, which is used for the boilers. Eighty-four thousand gallons per day is the wash water required, which is drawn from Toby Creek as long as any is available, and that failing, mine water is used. Slush, waste water and water used for cooling ashes are flushed to the mines, while the excess mine water enters Toby Creek below the breaker.

East Boston Breaker, East Boston Coal Co.

Most of the coal is prepared wet in the breaker, mine water being used for washing purposes. The slush and part of the waste water is flushed into the mines, but the remainder of the waste water with the excess mine water flows to Toby Creek.

No. 4 Breaker, Kingston Coal Co.

All sizes above buckwheat are prepared dry, though about 200 tons a day of this size are washed with mine water, requiring from 600 to 700 gallons per minute. The slush, waste water and ash pit drainage are flushed to the mines through two boreholes with still another in reserve. The mine water is pumped to a concrete reservoir, the overflow from which drains to Toby Creek.

No. 2 Colliery, Kingston Coal Co.

About 600 tons of coal, ranging in size from buckwheat to egg, are prepared wet, which required 1,200 gallons of mine water per minute. All slush, waste water and drainage from ash pit are flushed to the mines.

Woodward Colliery, Delaware, Lackawanna & Western Coal Co.

An average of 1,400 tons a day of rice, barley and buckwheat are prepared wet, averaging about 1,300 gallons of water per minute, which is pumped from Toby Creek. All mine rock is crushed and run to the mines with the slush, although when the boreholes become clogged a slush bank is utilized. The waste water goes to a small settling tank and drains with the mine water to Toby Creek. Water used in cooling ashes is settled and pumped back for use again, although some of it overflows to Toby Creek.

Boston Shaft and Washery, Delaware & Hudson Coal Co.

Since the removal of the breaker, all coal mined is taken to No. 5 Colliery for preparation, and the washery is washing only enough culm from the bank to supply the boilers. Slush from the washery is flushed to the mines, while the waste water and drainage from the ash pit flow direct to Creek No. 47.

Plymouth No. 3 Colliery, Delaware & Hudson Coal Co.

Approximately 600 tons of coal a day, in sizes from rice to buckwheat, are prepared in the washery, with water being pumped from the Susquehanna River at the rate of 500 gallons per minute, while the breaker ships the larger sizes dry. The slush is flushed to the mines, but the waste water, which is black in color and contains some culm, drains to Creek No. 47. No mine water is pumped out at this colliery.

Plymouth No. 2 Colliery, Delaware & Hudson Coal Co.

The larger sizes are prepared dry in the breaker, and the smaller ones wet in the washery, mine water being used. Slush from the washery runs to a borehole leading to the mines, while the overflow water from slush channel, waste water from the coal pockets and surface water about the breaker drain to Creek No. 47. The creek runs directly under the washery and receives considerable drip from it. No culm from the bank is now being prepared in the washery, the latter only being used as an annex to the breaker.

Plymouth No. 5 Colliery, Delaware & Hudson Coal Co.

The breaker prepares the large sizes dry and the washery the smaller sizes wet, using mine water for washing. The main slush line leads to the mines, but in case the boreholes clog the slush is run to a slush bank which drains with the mine and waste water to Creek No. 47. The washery is preparing enough fuel from a culm bank for the boilers besides acting as an annex to the breaker, and considerable fine culm from it reaches Creek No. 47, as is evident by the deposits in the bed.

No. 1 Shaft, Delaware & Hudson Coal Co.

Three large streams of mine water are pumped direct to Creek No. 47, as most of the mine water from No. 2, No. 3 and No. 5 workings is pumped out here.

Lance Colliery, Lehigh & Wilkes-Barre Coal Co.

Approximately 160 tons of rice and buckwheat coal, half of which is used for boiler fuel, is prepared wet, using wash water from the Susquehanna River, at an average of 675 gallons per minute. The mine and waste water run to the river, but the slush and ashes are flushed to the mines.

Dodson Colliery, Plymouth Coal Co.

All coal is prepared dry except about 125 tons a day smaller than pea (90% of which is used for boiler supply), which is washed with water pumped from the Susquehanna River, averaging 140,000 gallons in a 6-hour day. Slush is flushed to the mines, but when the borehole becomes clogged, a bank is utilized, well surrounded with rock, through which the waste water passes to the Susquehanna River. Mine water and drainage from the ash pit runs directly to the river.

Hillside Colliery, Bright Coal Co.

In the breaker the sizes of coal larger than pea are prepared dry, and from pea to buckwheat wet, using spring water for washing. All slush, waste water and drainage from the ash pit run direct to a branch of Browns Creek, which is full of culm all the way to the main stream near No. 4 Delaware & Hudson Shaft.

No. 4 Shaft and Washery, Delaware & Hudson Coal Co.

A small washery to supply fuel for boilers is washing culm from the bank, after which the slush and drainage from the ash pit is flushed into the mines, and the excess mine water is run direct to Browns Creek. Some of the slush and waste water from the scraper line is run to a small settling tank, which, in cleaning out, is flushed direct to the creek, carrying in a considerable quantity of culm.

Gaylord Breaker, Kingston Coal Co.

About 225 tons a day of rice and buckwheat are prepared wet, 55 tons being used for fuel, while all the larger sizes are prepared dry. Slush and waste water are pumped to three boreholes, so that nothing reaches Browns Creek except surface drainage after a storm.

The wash water is pumped from the Susquehanna River, and for four months the total pumpage was 23,000,000 gallons (about 460 gallons per minute). All rock and refuse is crushed and run with the slush to the mines, an overflow borehole being provided in case the pumps or slush lines break down.

Parrish Colliery, Lehigh & Wilkes-Barre Coal Co.

Sizes from pea coal down to rice are prepared wet in the washery, and the larger sizes dry in the breaker. The main slush line from the washery runs to the mines, but leakage from the slush lines, waste water from the washery, drip from cars and pockets, and water from the conveyor line all run direct to the Susquehanna River. Wash water in the washery is pumped from the mines, while the streams on the culm bank are supplied by river water. The ashes are flushed into the river, while the culm and ash banks border on its edge, every freshet washing portions of them away.

Nottingham Colliery, Lehigh & Wilkes-Barre Coal Co.

While the larger sizes are shipped dry, the smaller sizes from buckwheat to chestnut averaging 1,000 tons a day are washed, requiring about 2,160 gallons of water per minute, which is pumped from the Susquehanna River. All slush and drip water are flushed to the mines and the mine water runs direct to the river.

Reynolds Shaft, Lehigh & Wilkes-Barre Coal Co.

All coal is prepared at the Nottingham, and there is no drainage of waste or mine water whatever.

Red Ash No. 3 Washery, Red Ash Coal Co.

Culm is being washed down from the bank, using mine water pumped from a borehole back of the washery. All slush runs into Empire Creek and carries with it considerable fine culm.

Red Ash No. 2 Breaker, Red Ash Coal Co.

The sizes of coal above pea are prepared dry, while those smaller than pea receive wet preparation, using mine water. The slush runs to a bank and washes with the excess mine water into Empire Creek.

Empire Washery, Lehigh & Wilkes-Barre Coal Co.

Culm is carried in cars to the washery where it is washed with mine water. Although most of the slush is flushed to the mines, waste water quite black and full of culm reaches Empire Creek.

Stanton Colliery, Lehigh & Wilkes-Barre Coal Co.

Sizes of coal larger than No. 5 are prepared dry, and those smaller than No. 5 are washed with mine water in the annex. Usually the slush goes to the mines, but when a borehole becomes clogged it runs to an emergency slush bank, draining to Empire Creek. This creek, besides receiving waste and excess mine water, washes the edge of several culm banks.

Franklin Colliery, Lehigh Valley Coal Co.

Mine water is used for washing all sizes of coal from egg down, but sizes above that are prepared dry in the breaker. Slush and waste water are flushed to the mines, while the excess mine water is emptied into Empire Creek.

Maxwell No. 20, Lehigh & Wilkes-Barre Coal Co.

Most of the coal is prepared dry in the breaker, only No. 2 and No. 3 buckwheat being washed with mine water in the annex. The waste water and slush are flushed to the mines and the mine water is pumped to a storage reservoir that overflows to Solomons Creek.

Buttonwood Colliery, Lehigh & Wilkes-Barre Coal Co.

The new breaker here is not yet completed, although the washery is washing culm from a culm bank. All slush is flushed to the mines, and some waste and mine water drain direct to Solomons Creek.

No. 9 Colliery, Lehigh & Wilkes-Barre Coal Co.

In the breaker all coal is prepared wet with mine water stored in a reservoir, whose overflow runs to Creek No. 51. The slush is flushed direct to the mines, but the waste water is run to a slush bank which drains to Creek No. 51.

Hadleigh Colliery, Pittston Coal Mining Co.

Mine water is used in preparing all coal in the breaker. The slush is pumped to a slush bank, most of the effluent from which drains into the mines. A stream of mine water flows from the Hadleigh workings to Creek No. 51 near No. 9 Colliery (Lehigh & Wilkes-Barre Coal Company).

Loomis Colliery, Delaware, Lackawanna & Western Coal Co.

A new breaker is now under construction. The mine water is pumped to a rock bank, but is absorbed and does not apparently drain direct to any stream.

Warrior Run Colliery (Abandoned), Lehigh Valley Coal Co.

An old washery is still standing but it has not been operated for some time. A stream of mine water and wash from a culm bank reach Warrior Creek at this point.

Truesdale Colliery, Delaware, Lackawanna & Western Coal Co.

The preparation of the larger sizes in the breaker is dry, while the sizes from pea coal down are washed with mine water in the annex. The washery slush runs to a slush bank surrounded by rock, through which the waste water, black and carrying some culm, drains to Warrior Creek. The mine water is pumped to a reservoir built on the creek for supplying the washery, while part of the waste water drains direct to the creek and the rest runs to a settling tank emptying into the mines.

Bliss Colliery, Delaware, Lackawanna & Western Coal Co.

In the breaker the larger sizes are prepared dry and the smaller sizes wet, using mine water which is stored in a small reservoir nearby. All slush, waste water and excess mine water are discharged on the flats at the source of the Bliss Branch of Warrior Creek, so that a large quantity of culm is washed down with the creek.

Auchincloss Colliery, Delaware, Lackawanna & Western Coal Co.

The breaker prepares all larger sizes dry, and the washery the smaller sizes wet, using mine water which is pumped to a pond, and overflows to Warrior Creek. The slush from the washery runs to a settling tank, the dirty waste water draining down to a pond and the culm being hauled to a dump. Near the washery is a small slush bank for use when the settling tank is out of order; the outlet from this slush bank is full of culm.

Avondale Breaker, Delaware, Lackawanna & Western Coal Co.

This breaker prepares all sizes from buckwheat up dry, the only coal treated wet being for the boiler room and averaging about 2,000 tons a month. The water used in the breaker is pumped from Creek No. 53 and averages about 370 gallons per minute for a 7-hour day. The slush and ashes are flushed to boreholes leading to the mines, although a small stream of waste water and leakage from the slush trough runs direct to Creek No. 53.

Chauncey Colliery, George F. Lee Coal Co.

An average of 6,600 tons a month, including all sizes of coal up to egg, are prepared wet in the breaker. The wash water is pumped from Creek No. 53, which is chiefly mine water from the Avondale

Colliery, as all the water in the Chauncey workings drains to other mines. Slush from the breaker runs to a slush bank which drains through rock to Creek No. 53, but the waste water still contains some fine sediment and is black in color.

West Nanticoke, West Nanticoke Coal Co.

All coal mined is shipped to No. 6 Colliery (Susquehanna Coal Company) for preparation, while all the mine water inside drains to the Avondale workings.

No. 6 Colliery, Susquehanna Coal Co.

Sizes of coal from barley up to stove, averaging 1,200 tons a day, are prepared wet, using mine water and requiring 600,000 gallons in a 9-hour day, while all coal larger than stove is shipped dry. Slush and waste water are run to two settling tanks which discharge into the North Branch of Newport Creek, the effluent being full of culm. The excess mine water from washery supply tanks drains direct to the North Branch of Newport Creek.

Nanticoke Washery, Susquehanna Coal Co.

The average amount of coal washed is 750 tons per day, using mine water pumped from the North Branch of Newport Creek; the amounts required are 1,290 gallons per minute in the washery and 470 gallons per minute on the bank. The slush runs to a slush bank with the Pennsylvania Railroad fill as a barrier between it and the creek. No water could be found leaking through the bank whatever, but the dirty waste water from the washery runs direct to the North Branch of Newport Creek.

Wanamie No. 18 Colliery, Lehigh & Wilkes-Barre Coal Co.

Coal larger than pea is prepared dry, and the smaller sizes wet with mine water. The slush and part of the waste water is flushed to the mines, while the rest of the waste water and the excess mine water drain to the South Branch of Newport Creek. In case the boreholes become clogged, a slush bank, which drains to the same creek, is utilized.

Alden Colliery, Alden Coal Co.

All sizes of coal larger than No. 3 buckwheat are prepared dry, while the smaller sizes averaging 100 tons a day are prepared wet, using mine water and requiring about 300 gallons per minute. The slush and waste water are usually flushed to the mines, although two slush banks are provided to take care of the excess quantities. The mine water overflow from the washery supply runs direct to the South Branch of Newport Creek.

No. 7 Colliery, Susquehanna Coal Co.

All sizes from No. 3 buckwheat to pea coal are prepared wet, and sizes above pea are dry, the total daily output being about 1,600 tons, 500 of which are wet. Part of the slush is run to a slush bank situated at the junction of the North and South branches of Newport Creek and draining to them both. The rest of the slush and the majority of the waste water run direct to the South Branch, carrying with it considerable culm and silt. No inside flushing is yet done, but preparations are being made for it. The amount of water used in the breaker, which is pumped from the South Branch of Newport Creek, averages 1,190 gallons per minute.

Colliery No. 5, Susquehanna Coal Co.

The preparation is both wet and dry in sizes No. 3, No. 4, No. 5, No. 6 and No. 7, all the other sizes being dry only. The slush from the breaker is led by a trough to a point 150 feet east and then discharged on an open culm bank leading direct to Newport Creek, which washes in still more culm from the bank. The waste water from the breaker also flows through this culm and drains to Newport Creek. The mine water is pumped to a reservoir, which overflows to the creek, joining the other two streams above. This company has not tried in any way to prevent culm from reaching the Susquehanna River at this colliery.

Salem Breaker, E. S. Stackhouse Coal Co.

All sizes of coal up to egg are prepared wet, the wash water supply being obtained from two creeks, one just above the breaker and the other about a mile and a half farther down the river. The slush and waste water run to the Pennsylvania Canal, which drains into Shickshinny Creek, and thence to the Susquehanna River. The daily output of wet coal is about 120 tons, using possibly 100 gallons of wash water per minute.

Lee's Shaft, West End Coal Co.

All coal mined is sent to the West End Breaker for preparation, but some mine water runs from one of the openings into Black Creek.

West End Colliery, West End Coal Co.

Sizes of coal larger than stove are prepared dry, from stove to No. 1 buckwheat are both wet and dry, and smaller than No. 1 buckwheat are wet, about 32,000 tons of wet coal being shipped per month. The wash water, which is pumped from the Susquehanna River,

averages about 2,750 gallons per minute. Slush is pumped to a slush bank which drains to Black Creek, the effluent being dirty and carrying fine culm, but the waste water and mine water run direct to the Susquehanna River.

Eckley Washery, Lehigh Valley Coal Co.

Mine water is used in preparing all coal in this washery. The slush and waste water is run to a slush bank, the drainage from which, black and carrying culm, is the main source of Big Black Creek.

Drifton Colliery, Lehigh Valley Coal Co.

The entire daily output of about 1,300 tons is prepared wet, by the use of mine water pumped direct to the breaker. Breaker slush is first run to a settling tank; the silt is conveyed to a slush bank in nearly a dry condition, while the overflow from the settling tank drains to a small stream flowing near the colliery. Upon receiving the waste and mine water, this small stream becomes black in color and carries fine culm, although part of the sediment is removed by a small settling tank built across the stream just before it enters Cross Creek. The waste banks are too far removed to be subject to direct wash by any creek. A good proportion of the coal prepared at this colliery is taken from strippings of the Mammoth veins.

Highland No. 5 Colliery, G. B. Markle & Co.

In the breaker all sizes of coal are washed with mine water. All slush, waste and excess mine water are flushed to a channel which empties direct into Cross Creek, carrying a large quantity of fine culm.

Jeddo No. 4 Colliery, G. B. Markle & Co.

Both breaker and washery prepare all coal wet, using mine water, the slush from which is flushed to the mines. The waste water, which is black and carries culm, runs to a swamp that drains into Big Black Creek. Excess mine water flows through the Jeddo Tunnel and discharges into Little Nescopeck Creek.

Jeddo No. 7 Colliery, G. B. Markle & Co.

A small reservoir supplies mine water for washing all coal in the breaker, averaging about 1,000 tons a day. The slush is run to a settling tank which separates most of the silt from the water; thence the culm is hauled to a bank in cars, while the waste water drains either to the mines in dry seasons or to Big Black Creek in wet seasons when the ordinary mine pumpage is sufficient for washing purposes. Although the waste water is black, it does not carry much silt in suspension. Drip from the cars and breaker drain into strippings, from which most of the coal prepared at this colliery is secured.

Lattimer No. 4 Colliery, Pardee Bros. & Co.

In this breaker about 1,730 tons of coal per day are prepared wet with water pumped from the Lattimer Canal, averaging about 612,000 gallons for an 8½-hour day. The slush is run to a settling tank, the overflow from which is carried by a wooden trough to the Lattimer Canal at a point below Lattimer No. 3 Washery. This drainage, with the waste water from the breaker and the excess mine water, serves to turn the water in the canal black and load it with culm. Besides this, more culm is washed in from the waste banks nearby.

Lattimer No. 3 Washery, Pardee Bros. & Co.

About 100 tons a day are prepared with water pumped from the Lattimer Canal, averaging 900 gallons per minute. A settling tank removes some culm which is dumped on a bank, but much of it reaches the Lattimer Canal with the waste water. The culm and rock banks are not subject to direct wash, but the waste water flows over some low culm flats and carries sediment to the canal.

Harleigh Colliery, Harleigh-Brookwood Coal Co.

All coal, whether from strippings or the mines, is washed in the breaker with mine water, the daily output of 300 tons requiring approximately 378,000 gallons. The slush runs to a bank, which, like the breaker waste water, drains into the Lattimer Canal, both carrying fine culm in suspension.

Hazleton No. 1 Colliery, Lehigh Valley Coal Co.

The preparation of all coal in this breaker is wet, mine water being used for washing purposes. The slush runs through an open channel to a slush bank, which is so graded that the slush does not spread out and settle, but empties direct to Cranberry Creek carrying a large quantity of culm. Waste and excess mine water run direct to Cranberry Creek, carrying with them considerable culm, while the creek washes in still more culm from the adjacent banks.

Harwood Colliery, Harwood Coal Co.

Wet preparation is used for all sizes of coal, with mine water for washing. Slush is first passed over a fine screen and then run to a slush bank well surrounded by rock. The effluent is black in color but does not contain much sediment when it reaches Eagle Run. Waste and excess mine water drain to the same run.

Cranberry Colliery, A. Pardee & Co.

The entire output of 2,000 tons a day is prepared wet, using mine water and averaging about 1,000,000 gallons daily. From the breaker the slush runs to a settling tank; the silt is placed on a culm bank,

and the overflow waste water runs direct to Cranberry Creek, carrying some fine culm in suspension. A considerable quantity of fine culm has been deposited near the banks of Cranberry Creek, either by rain wash from the waste banks or by settlement from the waste water.

Black Ridge Colliery, Hazle Mountain Coal Co.

About 430,000 gallons of mine water is used to wash the entire daily output of 400 tons. The slush is run to a slush bank that drains into Big Black Creek and carries with it some culm.

Tomhicken Shaft, Lehigh Valley Coal Co.

The breaker has been abandoned and all coal is shipped to Hazleton Shaft Colliery for preparation. A stream of mine water is pumped from the workings to Big Black Creek.

Derringer Shaft, Lehigh Valley Coal Co.

The breaker has been removed and all coal mined here is prepared at the Hazleton Shaft Colliery. Mine water is pumped out and runs to Big Black Creek.

Slope No. 5, Hazle Mountain Coal Co.

The coal is prepared at the Black Ridge Colliery, while the mine water drains to Big Black Creek.

Gowen Shaft, Lehigh Valley Coal Co.

The coal from these openings is prepared at Hazleton Shaft Colliery, while the mine water pumped out runs to Big Black Creek.

Springbrook Washery, Lehigh Valley Coal Co.

Old culm banks are being rewashed at an average of 5,100 tons a month, or about 200 tons per day, using about 900 gallons of mine water per minute. All slush runs to an old stripping through which it drains to the Lehigh and Wilkes-Barre mines. At the time inspected the washery was idle, but all of the mine water and apparently most of the waste water, carrying some silt with it, drains to a wooden flume that discharges into Catawissa Creek.

Audenreid No. 4 Colliery, Lehigh & Wilkes-Barre Coal Co.

This colliery prepares all its coal, averaging 1,500 tons a day, by the wet process, using about 2,500 gallons of mine water per minute. The excess mine water and waste water drain directly

into Catawissa Creek, while the slush is pumped to one of two large slush banks, the first of which empties into Catawissa and the second discharges to a smaller settling bank and then into Catawissa Creek. A large proportion, though not all, of the silt in suspension is removed from the effluent before it reaches Catawissa Creek.

Honey Brook No. 5 Colliery, Lehigh & Wilkes-Barre Coal Co.

All coal, about 1,450 tons per day, is prepared wet, with water pumped from Hunkidori Creek, requiring 1,600 gallons per minute. Slush runs to an old stripping, although a rock bank is to be built which will prevent any overflow to the creek when the stripping fills up. The waste water runs directly to Honey Brook from the colliery, but all mine water drains to the No. 4 workings underground. Part of the Mammoth vein is worked by strippings.

Beaver Brook Colliery, C. M. Dodson & Co.

About 1,200 tons a day, the entire output, is prepared wet with mine water, requiring 2,500 gallons per minute for a 9-hour day. The slush is pumped to a slush bank which drains to Beaver Brook, although an overflow is provided direct to the brook in case the pipe clogs. At the time of inspection the slush bank was leaking so badly that most of the silt reached the brook, while the waste and mine water carry in additional culm from the banks. By means of a bucket scoop the silt is carried to a bank, which prevents the slush basin from filling up so rapidly.

Oneida Openings, Lehigh Valley Coal Co.

All coal mined at No. 1, No. 2, No. 3 and Main slopes is shipped to the Jeanesville Colliery for preparation. The mine water in No. 1 and Main slopes drains to a tunnel which empties into Little Tomhicken Creek, while the mine water in No. 2 and No. 3 slopes is carried through a tunnel into Big Tomhicken Creek just below its junction with South Tomhicken Creek.

McCauley Mountain Colliery, Beaver Valley Coal Co.

Mine water is used to wash all coal in the breaker, except in dry seasons when fresh water is pumped from Scotch Run. Storage tanks for mine water are under construction, while the breaker itself is being renovated. When completed, the culm will be removed from the slush by settling tanks and part of the waste water used again for washing. The mine water now drains to Scotch Run. There is a large deposit of culm on the level ground between the highway and the railroad, as formerly all slush was run to this point.

Midvalley No. 2 Colliery, Midvalley Coal Co.

Mine water is used to prepare all coal in this breaker, averaging 1,000 tons per day, the amount of water used being unknown. All the slush is run to a slush bank in the old creek bed, at the lower end of which occurs a gap that enables the waste water, full of culm, to reach Shamokin Creek. A new channel has been dug for the creek alongside the slush bank, the stream returning to the old bed just below it. Mine water overflowing from the reservoir is the source of Shamokin Creek.

Midvalley No. 1 Openings, Midvalley Coal Co.

The breaker has been removed and all coal mined is prepared at Midvalley No. 2 Colliery. Old rock and culm banks still occupy the old bed of the North Branch of Shamokin Creek, a new channel having been dug. Mine water from these openings is pumped to Shamokin Creek.

Richards Colliery, Susquehanna Coal Co.

An average of 28,200 tons per month is prepared, about half being "wet" and half "dry." Mine water is used for the wet coal, while all sizes are wetted in loading. Slush runs to a settling tank and mud elevator, and the silt removed is practically dry when deposited on the bank, but the waste water, black and containing fine culm, together with the overflow mine water, drains into the North Branch of Shamokin Creek. Culm and rock banks near this colliery are washed by the creek, further impregnating the same.

Pennsylvania Colliery, Susquehanna Coal Co.

About half the coal, ranging in size from buckwheat to stove and totaling 750 tons a day, is washed in the breaker with mine water, requiring about 1,111,000 gallons per working day of 9 hours. The slush from the breaker runs to settling tanks and mud elevators, after which the silt removed is piled on a bank and the waste water drains through a rock bank forming the source of Green Ridge Creek. As this stream receives direct drainage from the loading chutes, the water is black and carries fine culm in suspension.

Sayre Colliery, Lehigh Valley Coal Co.

At this colliery all sizes of coal receive wet preparation, an average of 1,200 tons a day requiring about 1,620,000 gallons of mine water for washing. All slush from the breaker runs to a settling

tank, the culm being removed to a bank by means of conveyors, and the waste water flowing to a large settling basin that drains into the Middle Branch of Shamokin Creek. This effluent from the bank, though black, carries little silt. When the breaker is idle, a quantity of mine water is pumped to the creek.

Reliance Colliery, Philadelphia & Reading Coal & Iron Co.

Mine water is used to prepare all sizes of coal, usually about 800 tons a day. Whenever possible, the slush is flushed to the mines, but in case the pipes become closed or the quantity too great, a slush bank is utilized which drains to Shamokin Creek. When the breaker is idle, all mine water drains to the creek, first passing over a culm bed deposited by the waste water.

Locust Spring Colliery, Philadelphia & Reading Coal & Iron Co.

The entire output of 2,100 tons a day is prepared with mine water, using about 5,000 gallons per minute. Slush runs to settling tanks and mud elevators; the culm removed is carried to the bank by conveyor lines and the waste water drains, with the excess mine and lip screen water, directly into Locust Creek. During high water the creek washes in culm from the adjoining banks. The washery has been shut down since 1912, but may reopen at any time.

Alaska Colliery, Philadelphia & Reading Coal & Iron Co.

The output of 1,100 tons is all prepared with mine water, which requires about 2,000 gallons per minute. The slush is flushed to the mines with a reserve borehole provided for emergencies. Mine water is stored in a reservoir, the overflow from which, with the waste water, drains to Locust Creek. An ash bank just above the reservoir washes into it during heavy rains. Fine culm, as well as some coarser material washed down from the banks, reaches Locust Creek with the waste water.

Enterprise Colliery, Enterprise Coal Co.

All sizes of coal up to stove are prepared wet, but at the time of inspection the breaker was shut down because of a fire inside the mine. The washery is preparing about 250 tons of coal from the banks, using approximately 1,000 gallons of mine water per minute. All slush from the breaker and washery is flushed to the mines through boreholes, while the overflow mine water and waste water drain into an old opening which eventually carries it back to the mines. The slush bank used for emergencies has not been operated since July 1913.

Corbin Colliery, Excelsior Coal Co.

Wet preparation is used for all sizes of coal, averaging about 650 tons a day and requiring 500 gallons of mine water per minute. The slush runs to a settling tank and mud elevators, the dry culm is removed to a bank, and the waste water from the tank drains to Shamokin Creek, carrying with it fine culm in suspension. The mine water is pumped from a slope farther down the creek to a reservoir near the breaker and the excess overflows to Shamokin Creek.

Greenough Colliery, Greenough Red Ash Coal Co.

About 500 tons a day are prepared wet and 500 dry, but the entire 1,000 tons is wet before it is loaded on the cars. Mine water is used for washing in the breaker, after which the slush is run to a bank, leaches through a rock bank and is the source of Quaker Run. The waste water from the loading chutes carries some culm in suspension to this same stream.

Scott Colliery, Susquehanna Coal Co.

About one-third of the daily output of 1,000 tons is prepared wet in the breaker, although all of it is washed in loading. The mine water used averages 648,000 gallons a day the overflow draining into Quaker Run. The slush is deflected to a bank which drains with the waste water from the loading chutes directly into Quaker Run carrying a large quantity of culm in suspension.

Buck Ridge Colliery, Buck Ridge Coal Mining Co.

All sizes of coal smaller than stove are prepared wet, averaging about 338 tons per day, requiring 800,000 gallons of mine water. The mine water overflow and the breaker waste water run untreated to Shamokin Creek, while the slush is partly flushed to the mines and partly run to a bank that drains to the same creek.

Big Mountain Openings, Philadelphia & Reading Coal & Iron Co.

Although the breaker and washery have been torn down, the drifts and slopes are still operated, the coal being taken to the Henry Clay Colliery for preparation. Mine water is pumped to Shamokin Creek from two of the slopes.

Henry Clay Colliery, Philadelphia & Reading Coal & Iron Co.

The daily outpnt of 1,150 tons is all washed in the breaker, usually with mine water, although in dry seasons Shamokin Creek is utilized. The water consumption averages about 1,670 gallons per minute

for a 9-hour day. Waste and overflow mine water run into Shamokin Creek. The slush goes to settling tanks and mud elevators, from which the waste water runs to the creek and the silt is pumped with about three times its volume of water up to a slush bank. An overflow trough is provided to carry the waste water from this bank into Shamokin Creek. The bank broke about a year ago during a heavy storm, and an enormous quantity of culm was washed down across the road into Shamokin Creek, in addition to flooding several houses nearby to a depth of three or four feet.

Bergen & Ryan, Bergen-Ryan Coal Co.

Three small drifts and a breaker under construction is the extent of this operation at present. The preparation is dry by hand, and the drifts are above the water level, so that no mine water has to be pumped. Later a slush bank will be constructed on the hill draining to Shamokin Creek.

Natalie Colliery, Colonial Collieries Co.

About 1,450 gallons of mine water per minute are pumped to the breaker for washing the coal, although part of the larger sizes is prepared dry. In order to prevent shortage of wash water in the dry season, mine water is stored in the old mine workings and is pumped out when needed. The slush and waste water runs to a bank which drains to Coal Run.

Hickory Ridge Colliery, Susquehanna Coal Co.

Wash water for the 1,200 tons daily is obtained from Coal Run and averages 1,411,038 gallons a day. About 800,000,000 gallons of mine water per month are pumped across the mountain into Quaker Run. The slush and waste water from the colliery run to a bank which drains into Coal Run.

Hickory Swamp Washery, Susquehanna Coal Co.

All coal mined at these workings is prepared at the Hickory Ridge Colliery, but culm from a large bank, usually about 160 tons a day, is prepared in the washery. Mine water averaging 744 gallons per minute is used for washing purposes, and the resulting slush is carried by conveyors to a high conical bank from which the waste water drains off in all directions and finally reaches Coal Run.

Colbert Colliery, Shipman Coal Co.

This company pumps 700 gallons of mine water per minute, all of which is used in preparing their output of 700 tons a day. The slush runs to a bank and then passes through a screen into Coal Run, carrying culm.

Luke Fidler Colliery, Susquehanna Coal Co.

Sizes of coal larger than stove are prepared dry, while the smaller sizes undergo a wet process, and all sizes are washed before loading, the average daily output of 700 tons requiring 277,200 gallons of mine water. The slush runs to a settling bank which retains most of the silt, although some of it reaches Coal Run with the waste water.

Bear Valley Colliery, Philadelphia & Reading Coal & Iron Co.

The daily output of 1,200 tons is all prepared wet, using mine water from the various drifts and clear water which overflows from the boiler supply tank. All slush runs to settling tanks and mud elevators, the silt being conveyed to a conical bank, while the waste water from the tanks and drainage from the chutes flow to a slush bank, where most of the silt settles out and the water drains to Carbon Creek. This slush bank overflow, although dirty enough to discolor the creek, does not contain much silt in suspension. Below the slush bank culm has been deposited, but it appears to have been there for a long time.

Sterling Openings, Philadelphia & Reading Coal & Iron Co.

All coal taken out at these openings is prepared at the Burnside Colliery. When the mine water is not required for washing at the Burnside it is discharged into Carbon Creek.

Burnside Colliery, Philadelphia & Reading Coal & Iron Co.

Part of the coal is prepared dry, but over 70% of it (about 900 tons a day) is washed with mine water, averaging 500,000 gallons per 9-hour day. The slush and waste water are pumped to a settling bank which drains to Burnside Creek; in fact this black water, carrying fine culm with breaker waste water, is the source of this stream.

Cameron Colliery, Susquehanna Coal Co.

The entire daily output of 1,550 tons is washed with mine water, the average daily consumption being 1,564,317 gallons. Slush and ash pit drainage are run to settling tanks and mud elevators, the silt removed is conveyed to a bank, while the waste water drains to Shamokin Creek. Breaker waste and surface water flow directly into the creek, carrying fine silt in suspension.

Buck Mountain Colliery, Lehigh Valley Coal Co.

With an output of 1,000 tons a day, about 200,000 gallons of mine water are used for washing purposes. A reservoir on the mountain side stores the mine water for the breaker supply, and all slush is run into the mines, although a stream of waste water, carrying some fine culm in suspension, flows into the South Branch of Mahanoy Creek.

Primrose Colliery, Lehigh Valley Coal Co.

This breaker has not been used since 1912, all coal being prepared at Park No. 2 Colliery. However, the mine water which is pumped out from the openings is the source of the Middle Branch of Mahanoy Creek, the quantity averaging 4,800 gallons per minute in the wet season and 1,800 gallons per minute in the dry season. When the colliery was in operation culm must have entered the stream, as the bed still contains quantities of it.

Park No. 2 Colliery, Lehigh Valley Coal Co.

The daily output of 1,825 tons is all prepared wet, requiring about 1,800 gallons of water per minute, secured partly from the mines and partly from the reservoir of the Wyoming Valley Water Company. The coarser silt is removed from the breaker waste water by means of a system of elevators, while the finer silt and waste water drain to the North Branch of Mahanoy Creek. Slush flows to a bank surrounded by flashboards which drains into the creek just below the colliery. Most of the coarser sediment settles on the bank, but the finer material is carried downstream and the creek bed has several large deposits.

Springdale Washery, Lehigh Valley Coal Co.

When running at full capacity about 1,000 gallons of mine water per minute are required to prepare the 700 tons daily output. The washery slush runs to a concrete settling tank from which the silt is taken to a bank by mud elevators and a conveyor line, while the waste water is pumped to a slush bank on the hill above. Part of the slush bank effluent is clear when it comes out of an old slope and the rest of it drains to the mines and is pumped out again at the new shaft. Except for wash from the culm banks, very little silt reaches the creek from this washery.

North Mahanoy Colliery, Philadelphia & Reading Coal & Iron Co.

To prepare the entire 1,500 tons a day wet, 3,300 gallons of mine water are required per minute. The slush first runs to settling tanks and mud elevators, part of the silt removed being flushed to the mines, and the rest runs to a slush bank draining to the North Branch of Mahanoy Creek. Waste water and overflow from the settling tank and excess mine water drain directly into the creek, carrying with them fine culm.

Mahanoy City Colliery, Philadelphia & Reading Coal & Iron Co.

In the breaker from 900 to 1,000 tons of coal are prepared wet daily, which necessitates the use of 2,000 gallons of mine water per minute. The breaker slush goes to a concrete settling tank, all the silt removed by the mud elevators being flushed to the mines, while the waste water, which is black and contains fine culm in suspension, runs to the North Branch of Mahanoy Creek.

Tunnel Ridge Colliery, Philadelphia & Reading Coal & Iron Co.

With a daily output of 500 tons, about 1,725 gallons of mine water are required per minute to prepare the coal. The slush flows to a settling tank in the breaker, from which the silt is carried by a conveyor line to a bank, while the waste water from the tank and the excess mine water drain directly into Mahanoy Creek. A large culm bank is being flushed into the mine workings under Mahanoy City, using a part of the excess mine water. The waste water stream emptying into the creek is black but does not contain much heavy culm.

Knickerbocker Openings, Philadelphia & Reading Coal & Iron Co.

Since the removal of the breaker several years ago, all coal mined has been shipped to the Ellangowan Colliery for preparation. Mine water is pumped into the bed of Waste House Run from an old drift.

Ellangowan Colliery, Philadelphia & Reading Coal & Iron Co.

All sizes of coal except broken and steamboat are prepared wet, using mine water and averaging 1,250 gallons per minute for a daily output of 2,000 tons. The slush runs to a settling tank near the breaker, the silt is removed by mud elevators, and the overflow waste water and mine water run to a channel leading to Waste House Run. Rock and culm banks near the colliery are washed directly by the stream.

Maple Hill Colliery, Philadelphia & Reading Coal & Iron Co.

For a daily shipment of 2,450 tons, including all sizes of coal up to broken, 6,000 gallons of mine water per minute are required. All slush goes to a settling tank and mud elevators remove the silt, part of it being flushed to the mines and part of it pumped to a bank which drains to Kebbers Run. The waste and overflow mine water go directly into Waste House Run, carrying fine silt in suspension.

St. Nicholas and Suffolk Collieries, Philadelphia & Reading Coal & Iron Co.

All sizes of coal, about 1,900 tons per day, are prepared wet, using 5,000 gallons of mine water per minute for a 9-hour day. The slush is first settled in tanks, and the silt, taken out by the mud elevators, is conveyed to a slush bank, while the waste water from the tanks and breaker, as well as the excess mine water, all flow direct to Waste House Run. There is no drainage from the slush bank either to Mahanoy Creek or Waste House Run.

Boston Run Colliery, Philadelphia & Reading Coal & Iron Co.

The entire daily shipment of 600 tons is prepared with mine water, of which 259,200 gallons are pumped per day. The silt that will pass through a 1/16 inch screen is flushed with the waste water to the mines, while the coarse material is pumped to a slush bank. The overflow and waste water, which are black and carry culm, run directly to Mahanoy Creek.

Gilberton Colliery, Philadelphia & Reading Coal & Iron Co.

About 490 tons are prepared daily, using 1,500 gallons of water per minute for a 9-hour day. Over 3,000,000 gallons of mine water are hoisted every 24 hours, and all excess over the breaker supply runs into Mahanoy Creek. From the breaker the slush runs to a settling tank, the silt being carried by a scraper line to a culm bank, while the waste water, black but carrying little culm, discharges into Mahanoy Creek. The mine water is hoisted in tanks instead of being pumped as is usual.

Draper Colliery, Philadelphia & Reading Coal & Iron Co.

Although 2,000,000 gallons of mine water are pumped every 24 hours, only 486,000 per 9-hour day are utilized in washing the 800 tons of coal prepared. Waste water from the breaker, which contains culm, flows untreated, to Mahanoy Creek. The slush and ashes from the boiler house are run to a settling bank draining to Mahanoy Creek.

Stanton Colliery, Harleigh-Brookwood Coal Co.

In the preparation of 1,000 tons a day, 2,000,000 gallons of mine water are pumped, most of which is used in the breaker. The slush runs down to a pump which is supposed to hoist the culm to a slush bank, allowing the waste water to reach Mahanoy Creek. This does not work well in practice, as most of the culm and silt flow with the waste water into the creek.

Mahanoy Creek near Boston Colliery

West Bear Ridge No. 2 Colliery, Harleigh-Brookwood Coal Co.

Mine water from the old slope drains directly into Mahanoy Creek. A new breaker is about to be constructed and the mines reopened.

New Breaker, Madeira-Hill & Co.

Across the creek from the Stanton Colliery a new breaker is under construction, whose capacity will be 3,500 tons. Mine water will be used in preparing all sizes of coal.

Girard Colliery, McTurk Coal Co.

A new breaker is under construction which should be in operation by the summer of 1915. The old slush bank which drains into Mahanoy Creek will be used as before. At present a large stream of mine water is pumped into Mahanoy Creek.

Indian Ridge Openings, Philadelphia & Reading Coal & Iron Co.

All coal mined here is prepared at Shenandoah City Colliery. Mine water is pumped into Shenandoah Creek, which has been flumed around the rock banks to prevent flooding of the workings.

Kehleys Run Colliery, Madeira-Hill & Co.

All coal is prepared wet, averaging 1,200 tons per day, with a mine water consumption of 800 gallons per minute. The slush runs to a pit under the breaker, and from there a conveyor line carries the silt to a slush bank, and the waste water goes to a settling tank near Kehleys Run, part of it being used to wash down culm from an old bank and the rest reaching the stream.

Plank Ridge Washery, Philadelphia & Reading Coal & Iron Co.

This washery has been idle since 1912. All coal from the openings is taken to Shenandoah City Colliery, and the culm banks are exhausted.

Shenandoah City Colliery, Philadelphia & Reading Coal & Iron Co.

Both mine water and fresh water from Shenandoah Creek, together totaling 1,000,000 gallons per day, are used in preparing an average output of 2,000 tons. The slush runs to a settling tank and mud elevators, the culm removed is flushed to the mines, and the waste and overflow water from the tank drain directly into Shenandoah Creek. In case of stoppage in the borehole, a slush bank has been provided to settle the slush. The water in the creek is black and contains sewage which is rapidly decomposed by the acids in the mine water.

Cambridge Colliery, Cambridge Coal Co.

In preparing 350 tons a day by the wet process, 500,000 gallons of creek and mine water are used. The slush runs through a wooden trough across the creek to a flushing borehole. Leaks in the trough are so large and numerous that most of the water and silt reach the creek and not the borehole. Culm is carried down by the creek from two banks which adjoin it nearby.

West Shenandoah Colliery, Philadelphia & Reading Coal & Iron Co.

All the mine water and some water from Shenandoah Creek are used in preparing the output of 2,000 tons a day; the quantity, however, is unknown. The slush runs to a settling tank and mud elevators or else to a slush bank, all of which drain into Shenandoah Creek. Culm reaches the stream at this point both from the breaker and slush bank drainage.

Kohinoor Shaft, Philadelphia & Reading Coal & Iron Co.

All the coal mined, as well as that taken from existing culm banks, is prepared at the West Shenandoah Colliery. There is no mine water drainage, but fine culm is washed to the creek in times of high water.

Hudson Washery, H. H. Smith & Co.

The wash water for this operation is obtained from a dam which is built across Shenandoah Creek below the washery. From the banks of the old Turkey Run Colliery this company is preparing about 300 tons of coal a day. All slush and waste water is run untreated to Shenandoah Creek.

Weston Colliery, Locust Mountain Coal Co.

Lump and steamboat coal are prepared dry, but the smaller sizes which amount to 500 tons a day go through a wet process, requiring 1,500 gallons of water per minute, which is pumped from the mines. The breaker has a capacity for 2,500 tons per day, and when the mines are developed the output should approach that amount. Slush runs to a settling tank and mud elevator, the silt is conveyed to a bank, and the waste water overflows to Shenandoah Creek. A small stream of mine water from the drifts and slopes above enters the creek near the colliery.

Oxford Washery, Oxford Coal Co.

This plant has been idle for some time, and, as the old banks of Packer No. 4 are about washed over, there is no liability that it will be reopened.

Shenandoah Creek, from Packer Colliery

Packer No. 4 Colliery, Lehigh Valley Coal Co.

In preparing the 3,000 tons a day all coal is washed with mine water, part of it pumped from the mines and part running from a drift by gravity. All slush, waste water and excess mine water are run to a slush bank draining to Shenandoah Creek. The effluent is black and contains fine culm, as may be seen by the culm deposits at the creek.

William Penn Colliery, Susquehanna Coal Co.

Part of the coal is prepared dry and part wet, the latter usually about 1,000 tons a day, which requires 500,000 gallons of mine water. The slush is pumped to a slush bank in a ravine a half mile farther downstream, the black culm bearing effluent draining to Shenandoah Creek. Waste water from the breaker with the excess mine water carry additional fine culm to the creek.

Packer No. 2 Shaft, Lehigh Valley Coal Co.

All coal mined here is prepared at Packer No. 4 Colliery. A considerable stream of mine water and culm from the banks pollute Lost Creek, which above this point has been clear.

Girard Mammoth Colliery, Girard Mammoth Coal Co.

The 800 tons of coal prepared a day are all washed with mine water pumped at the rate of 1,200 gallons per minute. All mine water, waste water and slush are run directly to Girard Creek, so that the stream is loaded to capacity with culm, but has sufficient current to carry it down to Shenandoah Creek.

Hammond Colliery, Philadelphia & Reading Coal & Iron Co.

In a 9-hour day 2,100,000 gallons of mine water are used to prepare the total output of 1,200 tons of coal. The settling tank and mud elevators receive the slush, the culm removed is conveyed to a bank and the overflow from the tank, with the breaker waste water and excess mine water, discharge into Girard Creek near its mouth in Shenandoah Creek. Culm is carried to the latter creek by the waste water and by wash from the adjoining banks.

Packer No. 5 Colliery, Lehigh Valley Coal Co.

At present all coal mined here is prepared at Packer No. 4 Colliery, although a new steel breaker is in course of construction. Mine water from the shaft is pumped into Shenandoah Creek.

Centralia Colliery, Lehigh Valley Coal Co.

About 2,188,800 gallons of mine water are required to prepare the coal in the breaker and flush the ashes to a settling bank, to provide for which all mine water is stored in a large reservoir. The culm and ashes are run to settling banks which drain to Big Mine Run and carry to that stream fine culm and ashes.

Bast Colliery, Philadelphia & Reading Coal & Iron Co.

To prepare 900 tons of coal a day about 3,000 gallons of mine water per minute are utilized, and 1,000 gallons per minute more are discharged into Big Mine Run. All slush goes through a standard Philadelphia & Reading settling tank and mud elevator system, the culm removed is conveyed to a bank and the waste water, with some silt in suspension, flows to Big Mine Run.

Locust Run Openings, Lehigh Valley Coal Co.

All coal mined here is shipped to the Centralia Colliery for preparation. In dry weather, when there is no overflow from the dams above the colliery on Locust Run, the stream is composed entirely of mine water pumped to it from these openings.

Potts Colliery, Philadelphia & Reading Coal & Iron Co.

For a daily output of 1,000 tons prepared wet, 1,760 gallons of mine water per minute are used for washing purposes. The slush is pumped to a slush bank in a ravine which drains to Highlanders Run, or in case the slush main becomes closed mud elevators remove most of the silt and the waste water drains to the same stream. In the opinion of the foreman the slush bank is more efficient than the settling tank and mud elevators. All the breaker waste water and overflow mine water, in addition to wash from rock banks, drain to Highlanders Run.

North Franklin Colliery, Philadelphia & Reading Coal & Iron Co.

The daily output averages 1,600 tons, all of which receives wet preparation with mine water which is pumped to a storage reservoir on the West Branch of Zerbe Run. The slush runs first to a settling tank which overflows to the creek. From this tank the silt is pumped up to a slush bank, large and well protected, draining to the creek above the aforementioned dam. Waste water from the breaker flows untreated to the West Branch of Zerbe Run. The amount of water used for washing is unknown.

Slush and Culm Banks at West Brookside Colliery

Katherine Colliery, Trevorton Colliery Co.

About 200,000 gallons of water are required per day, half of it pumped from the mines and half from Zerbe Run. The slush runs to a settling tank, from which the culm is loaded in cars and sold, while the waste water drains to the run. When there is no market for the culm, the slush is discharged on a slush bank so near the stream that most of the silt finds its way into Zerbe Run. Waste water from the breaker, carrying a little fine culm, also reaches the stream.

Williamstown No. 2 Shaft, Susquehanna Coal Co.

All coal mined here is shipped through a tunnel to the Williamstown Colliery for preparation. Mine water from these openings is the source of the West Branch of Rausch Creek.

Valley View Openings, Philadelphia & Reading Coal & Iron Co.

A drainage tunnel discharges mine water into the West Branch of Rausch Creek from these openings.

East Brookside Shafts, Philadelphia & Reading Coal & Iron Co.

Ashes and mine water from these openings drain to Wiconisco Creek, although all coal is prepared at the West Brookside Colliery.

West Brokside Colliery, Philadelphia & Reading Coal & Iron Co.

Approximately 864,000 gallons of mine water are required to prepare 1,000 tons of coal per day, which is the usual output. Slush and all other wastes run first to a settling box, being used over again, and the rest flushed on a large slush bank. The water, after seeping through a rock bank, still retains its black color but little silt when it discharges into Wiconisco Creek.

Williamstown Colliery, Susquehanna Coal Co.

The breaker prepares 1,300 tons of coal a day, using 875,000 gallons of water, and the washery about 175 tons a day, requiring 1,250,000 gallons of mine water. All slush runs to a large bank, protected only by flashboards, which is so high and its sides so steep that every rain washes culm into Wiconisco Creek.

Short Mountain Colliery, Susquehanna Coal Co.

The breaker prepares part of the coal dry and part wet, totaling 1,100 tons a day, the smaller sizes requiring 750,000 gallons of mine water per day for their preparation. Culm from a large bank is

prepared at the washery, which uses 1,500,000 gallons of water in washing 300 tons per day. From the breaker the slush runs to a settling tank, the silt being flushed on a bank, and the waste water runs to the washery and is used over again. The washery slush goes to a second tank, the waste water flowing directly to Wiconisco Creek, and the silt is pumped to a large slush bank that drains into the creek. Besides the fine culm carried in by the settling tank and slush bank effluents, the proximity of the latter to the stream causes quantities to be washed down by high water.

Blackwood Colliery, Lehigh Valley Coal Co.

For an average daily output of 1,000 tons, all prepared wet, 1,760 gallons of mine water per minute are used. The slush from the breaker runs by gravity to a settling bank, the waste water goes to a settling tank under the breaker, and the mine water to a storage tank,—all of them draining to Panther Creek. Considerable culm reaches the stream from the slush bank.

Middle Creek Washery, Philadelphia & Reading Coal & Iron Co.

The washery has been idle for some time, although all the buildings are intact. Mine water from the old workings drains to Middle Creek.

Good Spring Colliery, Philadelphia & Reading Coal & Iron Co.

All the coal, averaging 1,000 tons a day, is prepared wet with mine water, requiring 960 gallons per minute for a 9-hour day. The breaker slush is carried by a scraper line to a large settling bank, the drainage from which is black and contains fine silt. The settling area on the bank is large, but as regular outlet sluices are provided the finer culm is washed out to the creek. This effluent, with the breaker waste and overflow mine water, is the source of Good Spring Creek.

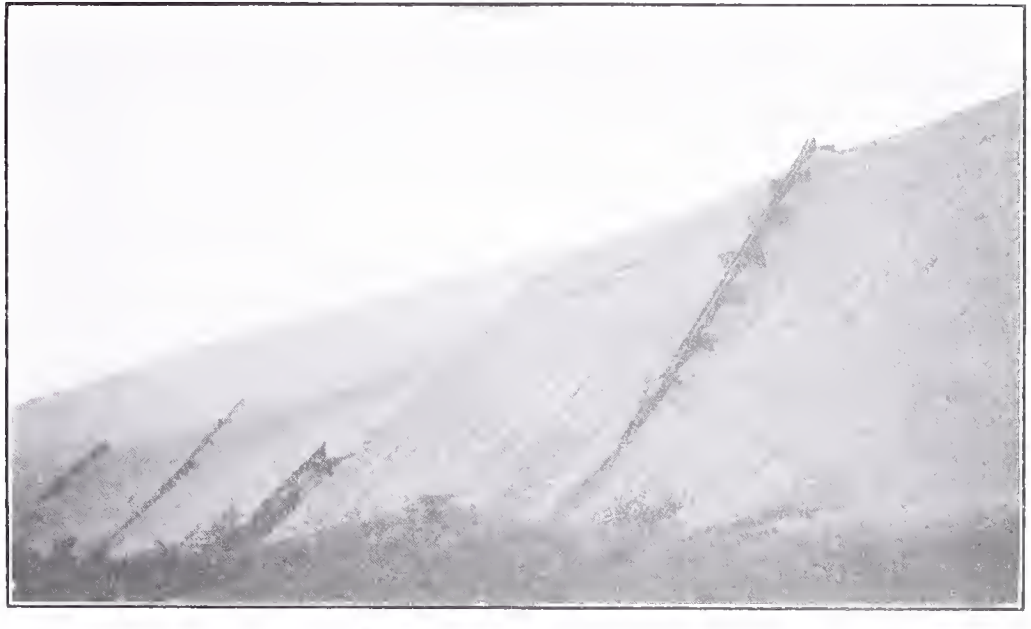
No. 3 Good Spring Slope, Philadelphia & Reading Coal & Iron Co.

All coal brought to the surface at this slope is prepared at the Good Spring Colliery. Mine water in considerable quantities is pumped to Good Spring Creek.

Pumping Station, Philadelphia & Reading Coal & Iron Co.

Over the divide from the Lincoln Colliery this station is pumping mine water to Lower Rausch Creek. It is entirely free from culm.

PLATE X



Short Mountain Colliery Slush Bank

Rausch Creek Washery, Philadelphia & Reading Coal & Iron Co.

Most of the culm banks have been rewashed and the washery is idle. Mine water from old openings flows to Lower Rausch Creek. When in operation the slush goes to a settling tank and mud elevators, draining to the same creek.

Lincoln Colliery, Philadelphia & Reading Coal & Iron Co.

All sizes but broken are prepared wet, an average daily output of 1,700 tons requiring 2,700 gallons of mine water per minute for 9 hours a day. The breaker slush flows by gravity to a large settling bank built across a ravine and draining into Stumps Run, and thence to Lorberry Creek. Waste and excess mine water drain directly to Lorberry Creek, carrying fine silt in suspension.

Upper Lehigh Colliery, Upper Lehigh Coal Co.

All sizes of coal are prepared with mine water, using about 700,000 gallons per day. The slush runs to a settling tank near Pond Creek, the silt being conveyed to a conical shaped waste bank, and the waste water, carrying quantities of culm, runs into the creek. The low banks of culm near Pond Creek are all subject to wash.

Old Pond Creek Colliery, Pond Creek Coal Co.

This breaker has not been in use for some time, as the mines which supplied it with coal are flooded. The building is directly over Pond Creek, and if operated would drain into it.

Fred Brandmaier's Colliery, Fred Brandmaier, Owner

The breaker is apparently abandoned, as the mines are flooded by Pond Creek.

Pond Creek Shaft, Pond Creek Coal Co.

The mines are flooded and have not been operated for some time. The old ash and rock banks stand near the creek and are subject to wash.

Highland No. 2 Colliery, G. B. Markle & Co.

All the coal, amounting to 850 tons per day, is prepared with mine water which averages 918,000 gallons for a 9-hour day. The slush runs out on a waste bank, and, after seeping through a rock bank, drains through a low culm flat to the headwaters of Sandy Run. The effluent is black and contains culm which is carried along by the swift current of the mine water entering above.

Sandy Run Colliery, M. S. Kemmerer & Son

The preparation of all sizes of coal is wet; about 1,800 gallons of mine water per minute are required for washing 350 tons per day. Slush from the breaker is run to a 1/16 inch screen, the silt which passes through flowing with the waste water to Sandy Run, while the coarser material is settled on a bank that also drains to the run. The cost of disposing of the slush, including labor and the cost of wooden troughs, is very small.

Old Buck Mountain Openings, Lehigh Valley Coal Co.

The breaker has been dismantled 25 years, and the coal is all prepared at the Eckley Washery. Most of the coal is taken from strippings, but the waste banks are far removed from any stream. Three streams of mine water from old openings drain to Laurel Run.

Hazleton Shaft Colliery, Lehigh Valley Coal Co.

The entire output, averaging 3,000 tons per day, is prepared with mine water, which is stored in a pond, the overflow reaching Hazle Creek. Slush from the breaker runs to a settling basin, the waste water draining to the creek and the silt being removed to a bank. Fine culm in the waste water discolors the creek, which is clear above this colliery.

Hazle Brook Colliery, J. S. Wentz & Co.

Mine water, averaging 1,000 gallons per minute for a 9-hour day, is required to prepare the 500 tons output. All slush and waste water are run partly by sluice and partly by open channel to a settling basin in an old creek bed and drain thence into Hazle Creek. The overflow from this bank carries fine silt and sulphur water into the creek.

Jeanesville Colliery, Lehigh Valley Coal Co.

All sizes of coal from No. 3 buckwheat up to broken, usually 2,300 tons a day, are prepared with mine water, requiring 3,000 gallons per minute. The breaker slush flows to two wooden settling tanks, the silt being carried by conveyors to a bank, and the water, still black with the waste and excess mine water, flows directly into Beaver Creek. The ash pit drainage is settled in four concrete tanks, but the effluent is not altogether free from silt.

Coleraine Colliery, A. S. Van Wickle Estate

For 800 tons of coal a day 756,000 gallons of mine water are required. The slush and waste water run to settling tanks which drain into the South Branch of Beaver Creek. Water used for flushing ashes is settled and utilized again in the breaker. Quantities of culm escape to the creek with the waste water from the tanks.

Beaver Meadow Colliery, Lehigh Valley Coal Co.

All sizes of coal are prepared wet, using approximately 890 gallons of mine water per minute for 9 hours a day to wash 1,000 tons of coal. Part of the breaker waste water, carrying a little fine silt, flows to Beaver Creek, but the breaker slush drains to a bank over an old stripping from which at the time of inspection there was no surface outlet, a borehole taking the water to the mines.

Evans Colliery, Evans Colliery Co.

Mine water is used to prepare all coal, which so far has not exceeded 100 tons a day, the wash water consumption being about 500 gallons per minute. The mine water overflow and drainage from the slush bank runs to Beaver Creek, carrying a little culm in suspension.

Penn Forest Breaker, Penn Forest Coal Co.

This breaker is under construction, but no coal has yet been mined nor any waste banks thrown up. The operation will be a small one.

New Hauto Washery, Lehigh Coal & Navigation Co.

About 670 tons a day are prepared from old culm banks, requiring 408,240 gallons of wash water which is pumped from Nesquehoning Creek. Slush from the washery is pumped to a settling bank which drains to the creek, as does also a small stream of waste water directly from the washery. The creek becomes a dirty brown below the washery, although it was clear above. Some banks of the old Hauto Washery are subject to wash in time of high water.

Summit Colliery, Lehigh Coal & Navigation Co.

This breaker has not been operated for two years, while all coal mined here is prepared at the Nesquehoning Colliery. The company's coal storage yards at this place, when loading, use fresh water which drips from the cars and carries a small quantity of silt to Nesquehoning Creek.

Nesquehoning Colliery, Lehigh Coal & Navigation Co.

All the coal, averaging 3,500 tons a day, is washed with fresh water pumped largely from Nesquehoning Creek with a small addition of mine water, the total being 3,000 gallons per minute. Slush is pumped to a settling bank bordering on Nesquehoning Creek and draining to it with a small stream of breaker waste and mine water from No. 1 Shaft. A quantity of culm is discharged into Nesquehoning Creek with the slush bank drainage, or washed in directly during high water.

Tuscarora Openings (Abandoned), Slattery Bros.

Culm banks are subject to wash by Tarmans Creek, while several streams of mine water flow from the old drifts.

Bell Colliery, Gorman and Campion

Wash water is pumped from the Schuylkill River and varies in amount with the water in the stream. Slush from the breaker runs to a settling bank that drains with the breaker waste water directly into the river. Mine water from a drift and wash from the adjacent culm banks produce additional pollution.

Maryd Colliery, Maryd Coal Co.

All sizes of coal are prepared with mine water, averaging 900,000 gallons per day. Slush from the breaker runs to a settling tank and mud elevators, the silt is conveyed to a bank and the waste water discharged into Swift Run. Mine water from the shaft and wash from the culm banks are additional sources of pollution. A new settling tank and mud elevators are under construction which will treat the effluent from tank No. 1, and will remove more of the silt.

Brockton Colliery, Schuylkill-Lehigh Coal Co.

The buildings are still standing, but the colliery has been abandoned. Mine water from the old workings flows to Big Creek.

Kaska-William Colliery, Alliance Coal Co.

This breaker has been closed down for the past two years, owing to a dispute with the Railroad Company over rates. Mine water from the Kaska-William openings is the source of Kaska-William Creek, which flows by culm banks subject to wash.

Silver Creek Colliery, Philadelphia & Reading Coal & Iron Co.

An average of 1,750 tons of coal are prepared daily with mine water, usually 997,200 gallons in a 9-hour day. The slush runs to a settling tank and mud elevator, the silt is conveyed to a bank, and part of the overflow water runs to a slush bank, while the rest drains into Silver Creek. Drainage from the slush bank is free of culm, clear and sparkling, but the waste water reaching the creek is black and contains a little silt. Mine water and the waste water from this colliery are discharged into Silver Creek. This slush bank gives the best effluent of any in the entire anthracite region.

Eagle Hill Colliery, Philadelphia & Reading Coal & Iron Co.

All sizes of coal, averaging 1,000 tons a day, are washed with mine water consumed at the rate of 1,600 gallons per minute for 9 hours a day. The slush runs to a settling tank and mud elevator, from which the silt is conveyed to a bank, and the waste water runs to a settling basin surrounded by rock and lined with ashes near the outlet. The effluent from this basin is practically clear when it drains into Zacharias Run, and is next to Silver Creek in clarity.

Lucy R. Colliery, Port Carbon Coal Co.

About 189,000 gallons of mine water are used to prepare 300 tons per day, including all sizes of coal shipped. The slush from the breaker is flushed to a bank, flows around a rock bank along the Philadelphia & Reading railroad tracks and through an opening into the Schuylkill River. The bank is not well protected and quantities of culm reach the river.

Middle Lehigh Colliery, Mill Creek Coal Co.

During the preparation of 800 tons of coal per day, mine water is used for 9 hours at the rate of 960 gallons per minute. Waste water from the colliery goes to a settling tank draining to Mill Creek. The slush is flushed to a settling bank surrounded by rock and well maintained and eventually drains into the creek, although there is no direct overflow. At times when there is a market for the culm all waste water and slush are run to settling tanks.

Morea Colliery, Dodson Coal Co.

About 1,750 gallons of mine water per minute are required to prepare the daily output of 1,400 tons. All slush runs to a settling tank, the culm is either loaded in cars and shipped or else conveyed to a bank, and the waste water runs to the mine water reservoir which overflows to Mill Creek.

Whip-poor-will Colliery, Crystal Coal Co.

This breaker has been abandoned, and there is no drainage to the stream from mines or waste banks.

Spruce Creek Shaft, Mill Creek Coal Co.

The old openings are being reopened, and when operated the coal will be shipped to the Middle Lehigh Colliery for preparation. Mine water will be pumped into Wolf Creek.

Newcastle Colliery, Darkwater Coal Co.

A new breaker is now under construction which will prepare all sizes of coal smaller than egg by the wet process. At present the mine water, averaging 1,000 gallons per minute, is pumped to Mill Creek.

St. Clair Colliery, St. Clair Coal Co.

A mixture of mine and creek water totaling 4,000 gallons per minute is used to wash the daily output of 1,000 tons. The slush is first run to tanks under the breaker, the silt conveyed to a bank and the waste water run to another large concrete tank from which it is pumped to a slush bank surrounded by rock. The effluent seeping through the bank is the origin of Little Wolf Creek, and although dirty contains little silt.

Mt. Hope Colliery, Mt. Hope Coal Co.

The combined quantity of water secured from Little Wolf Creek and by mine pumpage to prepare the 400 tons of coal per day is 648,000 gallons. Slush runs to a settling tank under the breaker, and the dirty waste water carrying culm drains into Little Wolf Creek.

Pine Forest Openings, Philadelphia & Reading Coal & Iron Co.

This breaker has been torn down, but the old culm banks remain. Mine water from the openings is the origin of Forest Creek.

Howard Colliery, White & Co.

About 400 gallons of mine water per minute are used to prepare the daily shipment of 225 tons. Part of the slush runs to a settling bank which has no apparent outlet, while the breaker waste water and remainder of the slush and excess mine water discharge into the bed of Norwegian Creek. Except in wet seasons this drainage is the origin of East Norwegian Creek. Some of the coal prepared at this colliery is obtained by rewashing old culm banks.

Wadesville Colliery, Philadelphia & Reading Coal & Iron Co.

This colliery uses 864,000 gallons of mine water to prepare all the sizes of coal amounting to 1,300 tons a day. The slush runs to a settling tank and mud elevators, the silt removed is conveyed to a bank, and the water runs, with all other breaker waste water, to a large reservoir, from which it is pumped to a slush bank. The effluent, often seeping through the surrounding rock bank, is black but contains little silt when it enters East Norwegian Creek.

Beechwood Openings, Philadelphia & Reading Coal & Iron Co.

All coal mined is prepared at the Wadesville Colliery. West Norwegian Creek has its origin in mine water pumped out from these openings.

Glendower, Richardson, Oakdale and Thomaston Openings, Philadelphia & Reading Coal & Iron Co.

In the order named these openings discharge mine water to the West Branch Schuylkill River. All send their coal to the Pine Knot Colliery for preparation.

Buck Run Colliery, Buck Run Coal Co.

An average of 216,000 gallons of mine water per day is required to prepare the coal in the breaker. The slush runs to a settling bank of large area but not well maintained, the drainage from which is the source of Buck Run. Breaker waste water is used to flush ashes to a bank that also drains to the same run.

Pine Knot Colliery, Philadelphia & Reading Coal & Iron Co.

During six months of the year this colliery uses creek water, and the other six months mine water, averaging 1,000,000 gallons, with which to prepare 1,700 tons a day. The slush runs to a well kept settling bank, surrounded by rock and lined with ashes, the effluent from which reaches the West Branch Schuylkill River. The waste water must percolate through a rock bank before reaching the river.

The Juggler Colliery, Butcher Creek Coal Co.

Spring water from mountain springs is used to prepare all the coal shipped from the breaker, averaging 60 tons a day. Slush runs to a settling bank which drains to the creek, turning it black but carrying little culm. The waste water is also settled before entering Butcher Creek, coming out almost clear. Culm banks subject to wash furnish most of the silt which reaches the stream.

Ellsworth Colliery, J. H. Davis Estate

Approximately three-fourths of the wash water is obtained from the mines and the remainder from natural creeks. The exact amount used to prepare the 175 tons a day is unknown. All drainage runs to a slush bank, and the effluent seems to find its way through boreholes into the mines, as very little reaches Butcher Creek. Most of the culm reaching this stream is washed in from the banks during floods.

Mine Hill Gap Openings, Philadelphia & Reading Coal & Iron Co.

All coal is prepared at the Pine Knot Colliery, while the sulphur water drains to the same mines underground.

Oak Hill Colliery, Oak Hill Coal Co.

Of a total daily output of 1,000 tons, 700 are prepared wet, using mine water, averaging 900 gallons per minute for 9 hours a day. Ordinarily the slush goes to a settling tank, the silt is removed by mud elevators and conveyed to a bank, while the tank overflow drains to the West Branch Schuylkill River. At the time inspected the elevators were broken and the slush ran direct to a small stream, draining thence to the river. The water is black and contains culm, as may be seen by the deposits in the river at the mouth of this stream.

Pine Hill Colliery, Pine Hill Coal Co.

Of the 1,200 tons shipped each working day 300 tons receive wet preparation, requiring 1,200 gallons of water per minute, which is secured from the mines. All drainage is run through a wooden trough to the Emperor Washery, where it is again used for wash water. Mine water is stored in a reservoir above the breaker.

Emperor Washery, Emperor Coal Co.

About 210 tons per day are washed from the old banks nearby, using part of the waste water from the Pine Hill Colliery for washing purposes. The washery slush is discharged partly to a settling bank and partly to Minersville Creek. The effluent from the bank reaches the creek black and full of culm.

Wolf Creek Washery, Wolf Creek Coal Co.

This operation was idle when inspected but had been working previously. All drainage appears to be direct into Minersville Creek.

Lytle Colliery, Lytle Coal Co.

All sizes of coal, usually 1,250 tons a day, are prepared wet with mine water, requiring 600,000 gallons. The slush runs to a series of settling compartments in a covered house, each tank being allowed to fill, settle and drain off successively, and the silt removed to a bank. The drainage from the tanks, breaker waste water and excess mine water—together making a considerable stream of black water with a little silt in suspension—form Lytle Creek, which empties into West-West Branch Schuylkill River.

Phoenix Park No. 3 Colliery, Philadelphia & Reading Coal & Iron Co.

An average of 1,000 gallons of mine water per minute are required to prepare 800 tons of coal per day. Slush from the breaker is either carried by conveyors or pumped to a settling bank which drains to a small stream running into West-West Branch Schuylkill River. In case the pumps break down the slush would be flushed to the mines or run direct to the river. Mine water is pumped out at a shaft near the breaker and also at the Peach Mountain Shaft directly into the West-West Branch.

John Veith Openings, Philadelphia & Reading Coal & Iron Co.

All coal brought to the surface here is shipped to the Otto Colliery for preparation. Mine water from the shaft drains to West-West Branch Schuylkill River, which passes several rock banks subject to wash.

Otto Colliery, Philadelphia & Reading Coal & Iron Co.

Of the 1,281,240 gallons of mine water pumped daily, 556,740 gallons are used for washing the 1,400 tons of coal prepared each day. The slush runs to a settling tank and mud elevators, the silt being conveyed to a bank and the waste water draining with the excess mine water to Muddy Branch Schuylkill River. Considerable fine culm reaches the stream with the above drainage.

Lansford No. 4 Openings, Lehigh Coal & Navigation Co.

Since the No. 4 breaker and washery have been taken down all the coal mined at No. 4 Colliery is prepared at No. 5 and No. 6 collieries, while culm from the old banks is taken to No. 12 Washery. Mine water pumped from No. 4 drift is the principal source of Panther Creek.

Lansford No. 5 and No. 6 Collieries, Lehigh Coal & Navigation Co.

These collieries adjoin and together average 3,500 tons a day, requiring 4,500 gallons of mine water per minute for washing. Slush from the breaker is pumped into a deep ravine that is enclosed at its mouth by a rock bank, behind which the silt is packed to a depth of 45 feet in places. The water seeps through, black but nearly devoid of silt, and part of it runs to the breaker supply tank and the rest to a dam on Panther Creek, from which it is pumped back to the breaker. Waste and excess mine water drain to Panther Creek and carry a little culm.

Coaldale No. 9 Openings, Lehigh Coal & Navigation Co.

The coal mined here is prepared at No. 8 Colliery, and culm from some of the old banks are being rewashed at the No. 12 Washery. Mine water is pumped directly into Panther Creek from a drift.

Coaldale No. 8 Colliery, Lehigh Coal & Navigation Co.

Approximately 3,180 gallons of water per minute, partly from the mines and partly from Panther Creek, are required daily to prepare wet 3,000 tons of coal. Slush from the breaker is pumped to a settling basin behind a rock bank, through which the effluent passes in reaching Panther Creek. This slush bank drainage is black and carries fine culm in suspension, while some waste water direct from the breaker and the ash pit effluent also contribute silt to the creek. Culm from the old banks is prepared in the annex.

Coaldale No. 12 Washery, Lehigh Coal & Navigation Co.

Culm from the banks at No. 4 and No. 9 openings, averaging 1,100 tons a day, is prepared at this washery with 364,500 gallons of water, which is pumped from a dam on Panther Creek. Slush runs to a settling bank surrounded by rock (used also by No. 10 and No. 15 collieries), the effluent from which carries fine silt to Panther Creek. A small slush bank below the washery removes part of the silt from the waste water, and the remainder reaches the creek above the dam.

Greenwood No. 15 Washery, Lehigh Coal & Navigation Co.

Fine coal from Rahn No. 11 Colliery is prepared here and averages 900 tons a day with a wash water consumption of 335,340 gallons, partly from the mines and partly from Panther Creek. The slush runs to settling tanks and mud elevators, the silt being conveyed to a bank in cars, and the waste water is run to the same slush bank as that from No. 10 and No. 12 collieries, draining to Panther Creek. A little drippage from the cars runs directly to the creek, but contains little culm.

Greenwood No. 10 Colliery, Lehigh Coal & Navigation Co.

In preparing 2,300 tons of coal per day by the wet process, 1,001,160 gallons of water are pumped from Panther Creek and the mines. Slush from the breaker runs to a settling tank and mud elevators, the silt is conveyed to a bank, and the waste water pumped to a slush bank draining to Panther Creek. Overflow mine water from the reservoir, with a small stream of waste water from the breaker, runs directly into the creek.

Rahn No. 11 Colliery, Lehigh Coal & Navigation Co.

A crusher and separator for sorting the sizes of coal are the only machines operated here at present. The larger sizes receive final preparation at the Tamaqua Colliery and the smaller sizes at No. 15 Washery. The only water used is supplied by a small hose to allay the dust and does not affect the creek. Mine water is pumped into a dam on Deep Hollow Creek.

Tamaqua Colliery, Lehigh Coal & Navigation Co.

For a daily average of 1,800 tons of coal, 743,580 gallons of mine water are used in the process of preparation. The slush is pumped to a settling bank, the effluent from which is black but does not seem to carry much sediment to Panther Creek. Water used in cooling the ashes is settled in a small basin, but the breaker waste water full of culm flows untreated to the creek. A reservoir on the hill stores all mine water, which is hoisted by tanks from the foot of the shaft.

Newkirk Openings (Abandoned)

A large volume of mine water is discharged from several old drifts into Wabash Creek.

East Lehigh Colliery, East Lehigh Coal Co.

In the preparation of 250 tons of coal per day, about 498,000 gallons of water, pumped from the Little Schuylkill River, are used. All waste water, slush and mine water are discharged directly into the river without any treatment whatever. Occasionally, when there is a market for the fine culm, settling tanks and mud elevators remove the silt, while the waste water goes to the river as before. Quantities of culm reach the Little Schuylkill River from this colliery.

CHAPTER IV

RIVER COAL RECOVERY OPERATIONS

More than 260,000 tons of merchantable coal, ranging in size from rice to chestnut, are annually recovered from the beds of the Susquehanna, Schuylkill and Lehigh rivers and their tributaries, in the pools, eddies and other sluggish portions of which, outside the coal measures, it had been deposited. Before the smaller or steam sizes of coal were used, quantities of coarse slate and coal were dumped on banks within the flood areas and in some cases directly into the streams, forming the source of the so-called river coal. During spring floods and the breaking of the ice gorges, deposits on bars or in pockets, as well as portions of the culm banks, subject to wash, are picked up and carried downstream. In recent years, however, since the introduction of washeries, many of the old banks have been removed and only the fine culm now reaches the streams from the collieries.

The culm is removed from the bed of the stream by a bucket or a suction dredge, passed over screens which allow the water and fine silt to return to the river, and after being conveyed to a landing on flatboats the coal is separated into commercial sizes.

From the Susquehanna River and two of its tributaries, Shamokin and Wiconisco creeks, the total recovery for 1914 by 47 commercial dredging operations will approximate 150,000 tons. In addition to the above, a small quantity of domestic coal is dug out by hand, amounting, during the season, to possibly 2,500 tons, giving a total for the watershed of about 152,500 tons, largely steam sizes.

Sixteen plants on the Schuylkill River recover approximately 59,000 tons of coal in a season, but the amount of domestic coal taken by hand from this stream is negligible.

Two operations on the Lehigh River, using 7 dredges, operating in slack-water behind the dams of the Lehigh Coal & Navigation Company, average annually 48,000 tons of steam coal.

The consensus of opinion among rivermen is that both the size and quantity of coal washed down by the streams is yearly decreasing.

SUSQUEHANNA RIVER

The River Coal Co., Buttonwood

An elaborate plant, consisting of a washery, pump dredges, flats and elevator lines, was assembled to prepare coal from the channel of the Susquehanna River opposite Plymouth. The venture proved a financial failure because of the quantity of ashes in the coal. When in operation about 75 tons a day were prepared and sold to the Wilkes-Barre Railway Company.

L. E. Hess, Beach Haven

The dredge and landing place are a mile above Beach Haven on the Susquehanna River and take out 2,000 tons a season, of which 75 tons are chestnut. When the conveyor line and railroad switch are completed, the steam coal should not cost over 80c a ton delivered at Berwick (40c per ton freight), whereas the unloading from flats and reloading to cars now costs $1.20 per ton at Berwick. The consumers, mainly the American Car & Foundry Company, pay $1.95 for this small coal delivered at the factory, while the domestic coal, which costs $1.50 a ton to prepare, brings $3.20 a ton at the boat.

Ray Hoffman, Almedia

This plant, consisting of one machine and five flats, recovers about 100 tons of domestic and 700 tons of steam coal from the Susquehanna River in a season. The landing place at Bloomsburg is leased jointly by Jerry Geese and the Hoffman Brothers for $25 a year. High water during the past spring and summer (1914) has increased the amount of coarse coal. The chestnut size, worth $4.00 a ton delivered, is sold to individuals, while buckwheat at $1.65 and rice at $1.25 per ton are used by manufacturing plants.

Reese Hoffman, Almedia

The digger and five flats produce about 150 tons of domestic coal, 600 tons of buckwheat, and 400 tons of rice, which sell for $4.00, $1.65 and $1.25 per ton respectively delivered at Bloomsburg. Haulage alone costs 85c from Almedia to Bloomsburg, where the large manufacturies are the principal consumers. The landing is leased at the latter place with Ray Hoffman and Jerry Geese.

Jesse Hopper, Almedia

With a small machine and five small flats the average yearly tonnage obtained is 350, most of it rice and buckwheat. The fine coal at $1.25 and $1.65 a ton is sold to industrial plants at Bloomsburg and the domestic coal at $4.00 to the farmers. The quantity of coarse coal has been larger than usual the past season.

Charles E. Custer, Almedia

An average of 1,200 tons, 90 of it domestic, is removed by the dredge and three flats from the bed of the Susquehanna River, either to the landing at Bloomsburg which is leased or to that at Almedia which is public. The sale price of the fine coal is $1.40 a ton delivered and the domestic coal cleaned is $3.50 a ton at the boat, while the cost to the operator is 70c at the landing. Manufacturers buy the fine and individuals the coarse coal.

Arthur Sharpless, Espy

The fleet, consisting of two dredges and 11 flats, takes about 2,500 tons of rice coal and 120 tons of pea in a season from the bed of the Susquehanna River; the former size is used by the Bloomsburg Heating Company, and the latter sold to individuals. In the past few seasons the ice floods have brought down considerable coarse coal,

this being particularly the case in 1914. The sale price of the rice coal is $1.30 delivered, and the cost price about 95c delivered or 35c at the landing, but the coarse coal is worth $2.00 a ton uncleaned, or $3.50 cleaned and delivered. The landing is the property of the Heating Company which is owned by Mr. Sharpless.

Reese M. Dawson & Son, Bloomsburg

Using a small pump dredge operated by a gas engine and two flats, the annual output is 425 tons, 75 of which is domestic coal. The fine coal is sold to manufacturers and the coarse to individuals, the buckwheat bringing $1.65 a ton delivered and costing 75c. The landing place is leased for a fixed sum of $25 a year.

Jerry Geese, Bloomsburg

About 1,000 tons of salable coal, 75 of which are domestic size, are dredged from the bed of the Susquehanna River by one machine and five flats, the landing place near the East Bloomsburg bridge being rented jointly with the Hoffmans for $25. For the buckwheat coal sold, to the industrial plants, he receives $1.65 a ton delivered, and for the domestic coal $4.00 per ton delivered.

Alfred Forney, Danville

At the public landing 900 tons of steam coal are taken out in a season by the dredge and two flats. This is sold to the Danville Water Company and manufacturers for $1.35 a ton delivered, 35c of this for haulage. Mr. Forney is of the opinion that both the quantity and quality of the river coal has deteriorated in the last few years.

Charles Forney, Danville

This operator recovers about 800 tons of steam and domestic sizes from the Susquehanna River, with one dredge and three flats, costing him $1.10 delivered. He unloads at a public landing and receives $1.35 and $3.50 per ton delivered respectively from manufacturers and individuals.

Benjamin Simmons, Danville

The annual yield of 400 tons, part domestic and part steam coal, is dredged from the Susquehanna River, and all conveyed to the public landing on two flats. Industrial plants around Danville take the steam size for $1.35, and individuals the domestic at $3.50 per ton delivered.

John Faust, Danville

The yearly output will average 400 tons, largely steam coal which sells delivered at the Price & Purcell Pipe Works for $1.35 per ton and a little domestic coal which brings $3.50 per ton. This operator has one dredge and two flats and unloads at a public landing.

Francis Steffen, South Danville

The average amount of river coal obtained in a season is 1,000 tons, the steam coal worth $1.35 and the domestic $3.50 per ton delivered. There is little profit in the coal at these prices. It is removed from the Susquehanna River bed by a dredge, loaded on flats, and towed to the public landing.

John W. Snyder, Kline's Grove

With one combination dredge and steamboat last season the output was 1,050 tons, but this year he is using two machines and will recover 1,200 tons, for which the sale price at the manufacturing plants in Northumberland is $1.10 a ton delivered. Though the amount of coarse coal is dropping off year by year, a little pea coal is found with the rice; the cost per ton to the operator is from 75c to 80c delivered. One landing at Northumberland is rented for $25 a year, but the Sunbury landings are public.

R. S. Fletcher, Northumberland

As in most places, the quantity of coal recovered depends upon the stage of the river, high water being essential to a successful season. With one dredge and three flats the daily average is from 15 to 20 tons, which amounts to 800 tons a year. The steam coal is sold to the Susquehanna Converting Company for $1.10 a ton delivered and costs the digger 85c. No royalties nor rentals for landings are paid.

James Ruch, Northumberland

A small machine dredges from four to five tons a day of buckwheat and chestnut coal, which is sold for $3.75 and $4.50 per ton cleaned and delivered. The consumers are private individuals in Northumberland and use in a year between 300 and 400 tons. No rent is paid for the landing.

Foster Moore, Sunbury

Having an equipment of one dredge and two flats, the annual recovery of rice, buckwheat and pea coal is about 400 tons, costing the operator 75c a ton and selling for $1.10. The chief consumer is the Sunbury Table Works, where the coal is landed without paying any royalties.

Harry Shaefer, Sunbury

The 400 tons of coal a year taken out by a dredge and two flats are sold as steam coal to the Sunbury Table Works at $1.10 a ton delivered. The coal of larger sizes is rapidly disappearing from the rived bed. To the operator the cost, including repairs and wages for himself, is 80c per ton.

Daniel Gaugler, Sunbury

The pump dredge averages four tons a day of pea and buckwheat, mostly the latter, which is sold to the Susquehanna Converting Company for $1.10 a ton, while the pea brings $3.50 a ton. Possibly 300 tons are taken out in a season, on which no royalties are paid.

Harry Beck, Sunbury

The dredge operates on Shamokin Creek near Sunbury from four to five months a year, furnishing six tons of steam coal a day to the Sunbury Water Company for $1.70 per ton delivered. The coal is screened but not sized; a royalty of 10c is paid to property owners and 35c a ton for haulage, making the cost of operation $1.33 a ton. For the season the output should average about 500 tons.

Allemann and Wolf, Sunbury

On Shamokin Creek the dredge and two flats remove about 3,500 tons a year, 3,000 of which are now stored awaiting a market. The principal consumer is the Northumberland County Gas & Electric Company, which pays $1.50 a ton for steam coal. Pea coal is fast disappearing from the bed of the creek.

Correll and Hartman, Shamokin Dam

The fleet consists of three machines and eight flats, averaging for the season 3,000 tons of steam coal, which is sold to manufacturers for $1.10 a ton delivered. Owing to the serious damage to machines and consequent repairs, the profits last season were almost nothing. The landing is public and no royalties are paid.

West and Hottenstein, Shamokin Dam

In the year 1913 the tonnage was 1,400, but in 1914, 1,200 will be the total, owing to unfavorable weather conditions. Heavy floods and ice gorge this season brought more coarse coal than usual down the Susquehanna. The coal is unloaded at a public landing and sold to local manufacturers at Sunbury for $1.10 a ton, costing the operator 81c per ton delivered.

Jared and Ed Witmer, Dundower

About 800 to 900 tons of steam coal are recovered in a season by the fleet, which consists of two machines and six flats. The manufacturers at Herndon pay $1.00 per ton delivered. Each sudden raise in the Susquehanna River causes vast quantities of fine silt to be picked up from the river bed.

Quincy Carl, Herndon

The new dredge and flats have only been used for a few weeks, but should take out from 400 to 500 tons a season. The selling price to the manufacturers is $1.00 a ton delivered, and the cost to recover ranges about 80c a ton. As Carl owns the landing no royalties are paid.

Simon Garret, Herndon

Last season the output was about 500 tons, all sold to the manufacturing plants as steam coal for $1.00 a ton delivered. No royalties are paid for a landing or for dredging rights. An average daily recovery of coal is from eight to ten tons (costing about 75c per ton delivered) although in the spring as high as 18 or 20 tons may be taken out.

Ferris Reinard, Port Trevorton

In 1913 about 400 tons were obtained by the machine and three flats, being partly domestic and partly rice coal, although all of it is sold to the farmers at $1.00 a ton for rice coal and $3.00 for domestic. This year has been a good one for the machines because of high water, although the coal is becoming smaller in size. A fixed sum is paid to property owners for the landing.

Norman Bickel, Port Trevorton

Between 400 and 500 tons are recovered in a season, part of it pea coal and the rest rice, which is sold to the farmers for $3.00 a ton and $1.00 a ton respectively. No royalties are paid for the landing, as it is on the operator's property.

Harry and Francis Hummel, Port Trevorton

With two dredges and five flats the annual recovery is about 900 tons, partly pea coal sold to the farmers for $3.00 a ton delivered, and partly rice which brings $1.00 a ton delivered. The operators own their landings and pay no royalties.

Swab and Zeigler, Elizabethville

This operation is on Wiconisco Creek, about a mile above Elizabethville, and averages 500 tons in a season. The fleet consists of a machine and flatboats, the size of coal obtained is No. 2 buckwheat, and the selling price $1.25 per ton. Royalties are paid to the property owners on a tonnage basis.

Millersburg Light, Heat & Power Co., Millersburg

The operation on Wiconisco Creek is 1½ miles from the mouth in the Susquehanna River at Millersburg. The dam is 10 feet high to the foot of the flashboards, which are used in order to get pondage for dredging out the coal to be used in the auxiliary steam plant. Formerly the coal was large in size, but now the fine material fills the headrace and seriously interferes with the turbines. The company recovers from 10 to 15 tons per day for five months in the year.

H. V. Lukens, Clarks Ferry

The annual output of 6,000 tons is shipped to the Harrisburg Light & Power Company for boiler use, at 55c a ton on the car or $1.05 a ton at destination. Royalties are paid to the Connor Estate at the rate of 2c a ton up to $25 a year. The equipment consists of a combination dredge and push boat, two flats, and an unloading crane. According to the report of the operators, the quantity of coal for the past two seasons has been large and the quality excellent, brought down by the everchanging currents in the Susquehanna River.

H. E. Lukens, Clarks Ferry

The Harrisburg Light & Power Company take the entire output of 6,000 tons, paying $1.05 a ton delivered at Harrisburg. Royalties of 2c a ton are paid to the Connor Estate for the use of the landing place. In ordinary seasons the tonnage may not exceed 4,000, but the past two years have been exceptional. The fleet consists of one combination dredge and push boat, three flats, and an unloading crane.

Zeigler and Liddick, Clarks Ferry

The annual tonnage of 6,500 is sold either to the Harrisburg Light & Power Company or the Duncannon Electric Company, and is rated as steam coal. Royalties of 2c a ton are paid to the Connor Estate, while the sale price delivered at Harrisburg is $1.05 a ton. More coal is found this year than at any time previously.

Harrisburg River Coal, Sand & Stone Co.

An annual output of 12,000 tons is recovered by the fleet of three dredges, three steamboats, and thirty flats, and is sold to individuals and manufacturing plants. The operating cost averages about 70c a ton, and the sale prices range from $1.10 to $2.00, usually $1.25 a ton. Rent is paid to the property owners for the landings at Broad Street, Market Street, and Division Street, Harrisburg.

Jacob Weimer, Harrisburg

With the assistance of the fleet belonging to Couffer Brothers of Steelton, the output for the present season was 6,000 tons, most of it sold under contract to supply the pumping station of the Harrisburg Water Company, at 85c a ton delivered. The rental for the landing place is $50 a year, and the cost price per ton is 75c. The equipment consists of a combination dredge and steamboat and four flats.

Harrisburg Light & Power Co., Harrisburg

The steam coal recovered from the Susquehanna River by the fleet, consisting of one combination dredge and push boat, three suction dredges, two push boats and thirty flats, for 1913 was 25,726.24 tons. The cost at the wharf was $.427 a ton and at the plant 77c a ton including haulage and unloading. No royalties are paid nor rental for landing, as the one used below the Walnut Street Bridge is public.

Stroh Bros. & Filling, Harrisburg

Approximately 5,000 tons a year are sold to the Commonwealth of Pennsylvania, for the operation of its heat and light plant, and to the City of Harrisburg, for the operation of its water and filter plant, and to local laundry companies, at prices ranging from 95c to $1.25 a ton. The rental paid for the landing is $75 a year, and the operating cost varies from 70c to 75c a ton. The fleet consists of two dredges, one steamboat and sixteen flats, requiring about four tons of soft coal a week for fuel.

John B. Hipple, Wormleysburg

The fleet consists of three dredges, three push boats, and 20 flatboats. Most of the coal is sold unsized as steam coal to the United Electric Company at $1.00 a ton delivered. The cost price per ton is 70c, and rent paid for the landing is $20 per year.

Santo & Speece, Harrisburg

About 800 tons of river coal are annually recovered by the dredge, push boat and eight flats, although the principal product is sand. All coal is sold unsized as steam coal to the United Cigar Manufacturing Company for $1.25 per ton delivered, the operating cost being variable. The landing was formerly the property of the operators, but has recently been condemned by the City in order to widen the street.

F. H. Downey, Harrisburg

According to the report of the operator, the annual recovery is 4,000 tons a year, but later reports indicate that he has supplied the Pennsylvania Steel Company and the Central Iron & Steel Company with 15,000 tons, and should reach 20,000 tons by the end of the season. River coal is taken out by two dredges, two push boats and 16 flats. The cost to the operator is 60c a ton and sells for 75c to $1.25 delivered. The landing is rented for a fixed sum annually.

Couffer Brothers, Steelton

In 1913 the operators took out about 1,000 tons of river coal, while this year the total is included with that of Jacob Weimer, of Harrisburg. The fleet, consisting of one dredge, one steamboat and three flats, is employed more for recovering sand than coal. The coal is sold to the Steelton Water Company and individuals at prices ranging from 75c to $1.00 a ton, and the operating costs are from 65c to 70c a ton. The landing is rented for a fixed sum yearly.

Strine & Flanagan, Steelton

The retail price for steam coal varies from 75c to 90c a ton delivered, and is sold to manufacturers and the different water companies. The equipment of one dredge, one push boat, and four flats is used as much for sand as for river coal. At Harrisburg a fixed sum is paid for the landing each year, though the recovered coal is unloaded at several different points.

William Hoff, New Cumberland

The combination dredge and push boat and five flats recover 2,000 tons of river coal, sold unsized to the Susquehanna Woolen Company and the Dye Works for 85c to 95c a ton. The cost of operation averages 70c a ton, and no royalties are paid for the use of the landing.

Abraham Lescher, Highspire

This coal recovery operation will average 8,000 tons in a season, all of which is sold to the Pennsylvania Steel Company and the Steelton Store Company at 75c a ton delivered. Rental is paid to the Pennsylvania Steel Company for the use of the landing, making the cost to the operator about 65c a ton. The equipment, which consists of one dredge, one push boat and six flats, does not grade the coal.

Abner Hoff, Highspire

The annual recovery ranges between 5,000 and 6,000 tons, which is sold to the Pennsylvania Steel Company unsized for 75c per ton delivered, from which is deducted the rental for the landing. The dredge, steamboat and four flats cost to operate and repair about 55c to 60c per ton output.

Patrick Moriarty, Columbia

Very little coal has been recovered from the river for the past few seasons, 110 tons being the total for the present year. Sand is found in large quantities but the coal is becoming scarce. The sale price to the Columbia Water Works is $1.00 a ton, screened but not sized. It has cost from 90c to $1.00 to remove a ton of coal, using a dredge, push boat and four flats, and if as unprofitable next season will be abandoned.

SCHUYLKILL RIVER

Harry Baker, Schuylkill Haven

During a working season of six months about 850 tons of river coal are recovered by means of a dredge, scraper lines and scows, from the bed of the Schuylkill River. The operator owns all the land along both sides of the stream where the dredge is working and therefore pays no royalties. All fine waste material is returned to the river.

Schuylkill Haven Drifted Coal Co., Schuylkill Haven

This operation is in the old bed of the Schuylkill River in North Manheim Township, below Schuylkill Haven, the waste water being impounded and does not escape to the new channel. With an equipment of a dredge, scraper lines and scows, about 3,000 tons are taken out in a season lasting six months. When this pocket of coal is worked out there will be no way for it to be replenished.

Petry & Bowen, below Schuylkill Haven

Approximately 750 tons of pea and buckwheat coal are recovered per year from the Schuylkill River bed. The equipment consists of a dredge, scows and screens, and for the use of a landing a fixed sum is paid per year.

Samuel Shoener & Son, Landingville

Rice, buckwheat and pea coal, about 4,000 tons a year, are removed from the Schuylkill River just below the highway bridge. The plant consists of a dredge, flats, scraper lines and screens. A royalty of from 3c to 5c a ton is paid to the riparian owners for landings and trespassing.

C. Arthur Fisher, Landingville

The equipment consists of a dredge, flats, scraper line and screens, which have a capacity of 75 tons a day, but do not average over 50 tons, of pea, buckwheat and rice. For the season the total should approach 6,000 tons. The property along the river is leased for a fixed sum per year. All the waste and silt is returned to the bed of the Schuylkill River.

Alspach & Bowen, Landingville

For the first three months this season the operator took out 500 tons, and should recover 1,300 tons by the end of the year. The plant is equipped with a dredge, flats, scraper line and screens, which turn out rice, buckwheat and pea coal. Riparian owners receive a rental of $25 a year for the landing.

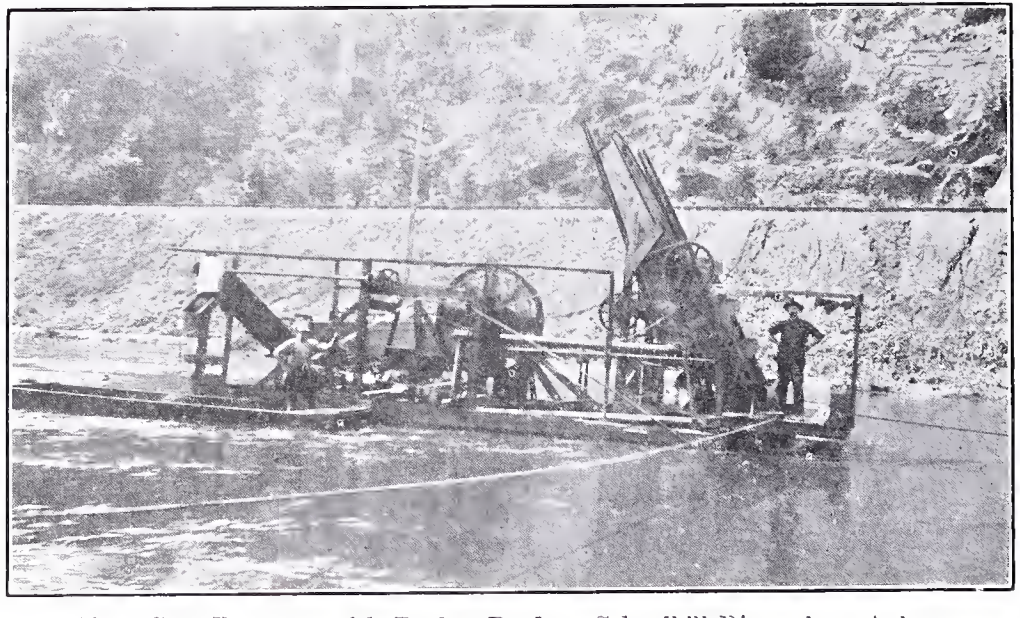
Louisa Mensch, Auburn

An average of 6,000 tons of rice, buckwheat and pea coal is annually recovered from the bed of the Schuylkill River, the equipment consisting of a dredge, flats, scraper line and screens. All the larger sizes of stone, slate, bone, wood and other rubbish are piled on the bank, although the sand and finer sizes are returned to the river. The operator lands the coal on her own property and pays no royalties.

Seltzer and Oswald, Auburn

With a dredge, flats, scraper line and screens about 5,000 tons of river coal is annually recovered. The property is leased from the riparian owners, all royalties being paid on the tonnage basis. Sticks, bone and other refuse are returned to the river.

PLATE XI



River Coal Recovery with Bucket Dredge, Schuylkill River above Auburn

Delaware Seamless Tube Co., Auburn

Between 4,000 and 5,000 tons of coal are annually recovered from the Schuylkill River by a plant consisting of a dredge, screens, and conveyor line, the daily quantity varying from 10 to 25 tons, depending entirely upon the stage of the river. Part of the property adjacent to the river is owned by the Tube Company and for the rest royalties are paid on the tonnage basis.

Uriah Mengel, Auburn

The outfit comprises a dredge, flatboats, a scraper line and screens, which in 1913 recovered 3,600 tons of river coal. Royalties are paid to the property owners on the tonnage basis, and all sticks, bone and other waste materials are piled on the bank. The coal is sold to manufacturers for 95c a ton delivered.

Nolan Coal Co., below Auburn

Between 2,000 and 3,000 tons of rice and buckwheat coal are stored on the bank near the washery. This elaborate plant has not paid and may be abandoned.

Crystal Coal Co., below Auburn

This new operation is near the Reading and Pennsylvania Railroad bridges below Auburn on the Schuylkill River. For the week during which it has worked the output was 125 tons, and should total 2,500 tons in a season. The equipment consists of a dredge, screens, flats and a scraper line, with which is obtained rice, buckwheat and pea coal. As the operator owns the adjoining property no royalties are paid for the landing.

Drifted Coal Co., Allemann and Wolf, Hamburg

The coal is recovered from the Schuylkill River by a dredge, cleaned, sized and loaded in flats, and conveyed to the landing by a small steamboat. About 4,000 tons of rice, buckwheat and pea coal are sold to the local manufacturers for boiler fuel. A royalty of 10c a ton is paid to the Schuylkill Navigation Company for the use of the canal and landing place at Hamburg.

A. P. Wertley, Berne

The equipment consists of a dredge, flats and screens for sizing.

Allemann and Wolf, Shoemakersville

The average output is between 4,000 and 5,000 tons of rice and pea coal, the former sold to local manufacturers for $1.25 a ton and the latter for $3.50 a ton. The equipment comprises two dredges,

flats, screens and a scraper line for unloading, and is one of the most efficient on the Schuylkill River. All sticks, bone and other large refuse are burned for fuel, while nothing but fine sand and silt at the dredge is returned to the stream. For the use of the landing a fixed sum is paid to the property owner.

Allemann and Ebersole, Reading

The two dredges, with the accompanying flats, screens and scraper lines, recover 10,000 tons of rice, buckwheat and pea coal in a season. For rice the sale price is $2.25 per ton delivered; for buckwheat $2.75; and for pea $4.50, the haulage costing from 30c to 50c a ton. A royalty of 5c a ton is paid to the property owners for the use of the landing.

LEHIGH RIVER

E. C. Luther & Co., Mauch Chunk

The two dredges have only been operated for a short time but together average 50 tons a day. Royalties are paid to the Lehigh Coal & Navigation Company, on the tonnage basis, for the use of the canal and landing of the New Jersey Zinc Company, which is the principal customer. The coal is sold for $1.00 a ton unsized, delivered at the dock. All wastes from the dredges return to the Lehigh River.

Drifted Anthracite Coal Co., Bowmanstown

A yearly output of 42,000 tons is recovered by the five dredges and its accompanying fleet of flats, three of the machines operating in the Parryville Dam and the other two in Lehigh Gap. After being screened on the dredge, all the coal is loaded on flats and conveyed by tugs to the plant of the New Jersey Zinc Company, which pays $1.00 a ton for it on the dock. Haulage is paid to the Lehigh Coal & Navigation Company on the basis of lockage, not mileage.

APPENDIX

TABLE No. I.—*Showing Location, Tonnage and Preparation of the Anthracite Collieries of Pennsylvania*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 1913 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Disposition per Ton of Output	Remarks
Lackawanna River,...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Lackawanna River,...	1	.....	.....	(1) Stillwater,	Stillwater Coal Co.,	.....	.....	.....	.....	.....	No drainage,	.....	.....
		.....	.....	Clifford Washery,	Penna. Coal Co.,	.....	Wet,	.....	216,000	Mines. Lack. River in dry season.	Slush bank, drains to Lackawanna River.		Not working.
Lackawanna River,...	.....	.....	.....	Forest City,	Penna. Coal Co.,	523,411	Wet and dry, ..	1,000	810,000	Mine water,	Slush bank drains to Lackawanna River. Waste water direct to Lackawanna River.		
Lackawanna River,...	2	Meredith Brook,	.....	4 openings,	{2 Penna. Coal Co., / 2 D. and H. Coal Co., }	.....	.....	.....	.....	.....	Mine water to Meredith Brook.		
Lackawanna River,...	3	Clarks Creek,	Trout Creek,	Clinton Falls,	Clinton Falls Coal Co.,	6,863	Wet and dry, ..	.....	37,500	Trout Creek,	All waste water and slush direct to Trout Creek,	.....	No effort made to remove culm.
Lackawanna River,...	4	Hudson Creek,	.....	East Side Openings,	D. and H. Coal Co.,	.....	.....	.....	.....	.....	Mine water to Hudson Creek.		
Lackawanna River,...	.....	.....	.....	Clinton Colliery,	D. and H. Coal Co.,	410,511	Wet and dry, ..	.....	1,175,040	Lackawanna River,	Slush bank, draining to Lackawanna River,	.01390	
Lackawanna River,...	5	.....	.....	North West,	Sterrick Creek Coal Co.,	187,787	Wet,	.....	150,000	Lackawanna River,	Slush bank, draining to Lackawanna River.		
Lackawanna River,...	6	Elk's Creek,	.....	Buffalo,	Outlook Coal Co.,	.....	Wet and dry, ..	.....	.....	.....	.....	.....	At present not working.
Lackawanna River,...	.....	.....	.....	Black Diamond,	N. Y. O. and W. R. R. Co., ..	.....	.....	.....	.....	.....	Mine water to Lackawanna River,	.....	Abandoned.
Lackawanna River,...	7	Coal Brook,	.....	Tappans	Geo. Tappan,	.....	Wet and dry, ..	.....	.....	Mine water,	Slush bank, drains back to mines.	.....	
Lackawanna River,...	8	Fall Brook,	.....	Coal Brook,	D. and H. Coal Co.,	677,240	Dry,	.....	.....	.....	.....	.00980	
Lackawanna River,...	.....	Fall Brook,	.....	Murrins,	Fall Brook Coal Co.,	4,780	Wet and dry, ..	100	80,000	.....	All waste water and slush direct to Fall Brook,	.....	No attempt to remove culm.
Lackawanna River,...	.....	.....	.....	G. Giles,	G. Giles,	.....	Dry.	.....	.....	.....	.....	.....	
Lackawanna River,...	9	.....	.....	3 pumping stations,	D. and H. Coal Co.,	.....	.....	.....	.....	.....	Mine water direct to Lackawanna River.		
Lackawanna River,...	10	Lee's Creek,	.....	Thomas Walker,	Thomas Walker Coal Co.,	.....	Dry.	.....	.....	.....	.....	.....	
Lackawanna River,...	.....	Lee's Creek,	.....	No. 4 Tunnel, Powderly,	D. and H. Coal Co.,	.....	.....	.....	.....	.....	Mine water to Lee's Creek,	.....	Clear mine water to Lee's Creek.
Lackawanna River,...	.....	Lee's Creek,	.....	South End,	South End Coal Co.,	.....	Dry.	.....	.....	.....	.....	.....	
Lackawanna River,...	11	Powder Brook,	.....	Wachna,	Wachna-Taylor Coal Co.,	6,853	Dry.	.....	.....	.....	.....	.....	
		.....	.....	Sacandago,	Sacandago Coal Co.,	1,610	Wet,	125	.....	Mine water,	Slush direct to swamp, where Powder Brook has its source.	.....	Waste water carried under Carbondale by terra cotta culvert, contains considerable sediment.
Lackawanna River,...	.....	Powder Brook,	.....	Bolands,	Carbondale Mining Co.,	31,672	Wet,	150	.....	Mine water,	Slush direct to swamp, where Powder Brook has its source.	.....	Waste water very dirty, much culm.
Lackawanna River,...	.....	Powder Brook,	.....	Powderly No. 2,	D. and H. Coal Co.,	366,541	Wet,	.....	1,337,960	Mine water,	Slush bank, dirty effluent to Powder Brook,	.05550	
Lackawanna River,...	.....	Powder Brook,	.....	Erie,	Penna. Coal Co.,	185,975	Wet and dry, ..	450	324,000	Mine water,	Most of slush is flushed to mine. Waste and drip water direct to Powder Brook.	.....	Waste water carries fine culm.
Lackawanna River,...	12	Shore Creek,	.....	Stone's Mines,	Stone's Coal Co.,	.....	Dry.	.....	.....	.....	.....	.....	
Lackawanna River,...	13	Aylesworth's Creek,	..	Keystone,	Sullivan and Schraeger,	.....	Wet and dry, ..	.....	.....	Mine water,	Waste water direct to Aylesworth's Creek, ..	.....	Stream small, but black, little sediment.
Lackawanna River,...	14	Rush Brook,	.....	West Mountain,	West Mountain Coal Co.,	20,011	Dry.	.....	.....	.....	.....	.....	
Lackawanna River,...	.....	Rush Brook,	.....	Fireside,	Fireside Coal Co.,	.....	Wet,	.....	10,000	.....	Waste water direct to Rush Creek,	.....	Carries silt and culm.
Lackawanna River,...	.....	.....	.....	Jermyn,	D. and H. Coal Co.,	395,083	Wet and dry, ..	.....	1,656,000	Lackawanna River,	Slush either to mines or to slush bank. Waste water direct to Lackawanna River.	.03400	
Lackawanna River,...	.....	.....	.....	.....	D. and H. Coal Co.,	.....	.....	.....	.....	.....	.....	.....	
Lackawanna River,...	15	White Oak Run,	.....	Drift,	Archbald Coal Co.,	114,565	Wet and dry, ..	.....	30,000	Mine and surface water,	Stream of mine water to Lackawanna River,	.....	Opposite Jermyn.
Lackawanna River,...	.....	White Oak Run,	.....	Binghamton,	D. and H. Coal Co.,	.....	.....	.....	.....	.....	Slush bank drains to White Oak Run,	.01000	Effluent black, carries fine culm.
Lackawanna River,...	.....	.....	.....	Drift,	D. and H. Coal Co.,	.....	.....	.....	.....	.....	Some mine water to White Oak Run.		
Lackawanna River,...	16	Laurel Run,	.....	Drift,	D. and H. Coal Co.,	.....	.....	.....	.....	.....	Some mine water to Lackawanna River.		
Lackawanna River,...	.....	.....	.....	(2) Openings,	Humbert Coal Co.,	.....	.....	.....	.....	.....	Mine water to Laurel Run.		
		.....	.....	Gravity Slope,	D. and H. Coal Co.,	324,616	Wet,	.....	1,186,800	Lackawanna River,	Slush bank draining to Lackawanna River. Waste water direct to Lackawanna River.	.01700	
Lackawanna River,...	17	.....	.....	Openings,	Humbert Coal Co.,	.....	.....	.....	.....	.....	Mine water to No. 17 Creek.		
Lackawanna River,...	18	Grassy Island Creek,	.....	Sunnyside,	Humbert Coal Co.,	77,508	Wet,	60	.....	Grassy Island Creek,	Slush bank draining to Grassy Island Creek. Waste water direct to Grassy Island Creek.		
Lackawanna River,...	.....	Grassy Island Creek,	.....	Dolph,	Dolph Coal Co.,	113,214	Wet and dry, ..	.....	.....	Mine water,	Slush bank draining to Grassy Island Creek,	.....	Not working; mine flooded; may be abandoned.
Lackawanna River,...	.....	Grassy Island Creek,	.....	Mt. Jessup,	Mt. Jessup Coal Co.,	307,184	Wet,	.....	.....	Lackawanna River,	Slush bank draining to Grassy Island Creek. Waste water from breaker direct to Grassy Island Creek.		
Lackawanna River,...	.....	Grassy Island Creek,	.....	North American Washery,	North American Coal Co.,	.....	Wet,	.....	540,000	Lackawanna River,	Slush bank draining to Lackawanna River.		
Lackawanna River,...	.....	.....	.....	Sterrick Creek,	Sterrick Creek Coal Co.,	449,628	Wet,	.....	375,000	Mine water,	Part of slush to mines, and rest to Lackawanna River.		
Lackawanna River,...	19	.....	.....	Riverside,	Scranton Coal Co.,	95,047	Dry,	.....	.....	Mine water,	Slush runs directly to No. 19 Creek.		
Lackawanna River,...	.....	.....	.....	Peck's Shaft,	Mt. Jessup Coal Co.,	.....	Wet,	.....	.....	Mine water,	About one-half waste water direct to Lackawanna River. About one-half to slush bank drains to Lackawanna River.	.....	Tonnage with Mt. Jessup breaker.
Lackawanna River,...	20	Sterrick Creek,	.....	Grassy Island Shaft,	D. and H. Coal Co.,	.....	.....	.....	.....	.....	Mine water runs direct to Sterrick Creek.		
Lackawanna River,...	21	Miller's Creek,	Wild Cat Creek,	Ridge Shaft,	Scranton Coal Co.,	.....	.....	.....	.....	.....	Mine water to Wild Cat Creek.		
Lackawanna River,...	.....	Miller's Creek,	Wild Cat Creek,	Raymond,	Scranton Coal Co.,	253,012	Wet and dry, ..	.....	157,500	Mine water,	Waste water direct to Wild Cat Creek. Slush bank drains to Wild Cat Creek.		
Lackawanna River,...	.....	Miller's Creek,	E. Branch Tinklepaugh,	Sturges Shaft,	Scranton Coal Co.,	.....	.....	.....	.....	.....	Mine water to E. Branch Tinklepaugh.		
Lackawanna River,...	.....	Miller's Creek,	W. Branch Tinklepaugh,	Ontario,	Scranton Coal Co.,	265,650	Wet and dry, ..	550	144,000	Mine water,	All slush direct to W. Branch Tinklepaugh Creek.		
Lackawanna River,...	22	.....	.....	Lackawanna,	Sterrick Creek Coal Co.,	247,609	Wet and dry, ..	.....	480,000	Mine water,	Slush water to mines. Breaker waste water direct to No. 22 Creek.		
Lackawanna River,...	23	Bull's Creek,	.....	Drift,	Sterrick Creek Coal Co.,	.....	.....	.....	.....	.....	Mine water to Black Creek.		
Lackawanna River,...	.....	.....	.....	Olyphant,	D. and H. Coal Co.,	827,930	Wet and dry, ..	.....	2,323,110	Lackawanna River, ..	Breaker slush to slush bank or mines. Washery slush direct to Lackawanna River.	.01800	
Lackawanna River,...	24	Eddy Creek,	.....	Markwood,	Moosic Mt. Coal Co.,	251,256	.....	.....	.....	.....	Mine water to Eddy Creek.		
Lackawanna River,...	.....	Eddy Creek,	W. Branch Eddy Creek,	Carey and Brown,	Carey and Brown Coal Co.,	21,782	Dry.	.....	.....	.....	.....	.....	
Lackawanna River,...	.....	Eddy Creek,	.....	Underwood,	Penna. Coal Co.,	.....	Wet and dry, ..	.....	.....	Mine water,	Slush run to swamp behind rock bank, will eventually drain to Eddy Creek.	.....	Breaker not completed. Began working April 28, 1914.

TABLE No. I—*Continued*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 1913 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Disposition per Ton of Output	Remarks
Lackawanna River,...	.....	Eddy Creek, ...	.....	D. and H. Shaft, ...	D. and H. Coal Co., ...	.....	.....	.....	.....	.....	Mine water to Eddy Creek.		
Lackawanna River,...	.....	.....	.....	Eddy Creek, ...	D. and H. Coal Co., ...	551,410	Dry, ...	.....	.....	.....	Drip from boiler room runs to Lackawanna River.	.04520	
Lackawanna River,...	25	Price Creek, ...	.....	Johnson, ...	Scranton Coal Co., ...	350,934	Wet and dry, ..	.....	126,000	Mine water, ...	Slush is run to mines. Waste water drains to Price Creek.		
Lackawanna River,...	26	.....	.....	Pancoast, ...	Price-Pancoast Coal Co., ...	637,407	Dry, ...	.....	.....	Mine water, ...	Mine and waste water to No. 26 Creek, ...	.....	Dry preparation, though a little water is needed in loading.
Lackawanna River,...	27	Smith Creek, ...	.....	Brickette Works, ...	Scranton-Anthracite Brickette Co.	.....	Wet, ...	.....	.....	Mine water, ...	Waste water runs direct to Smith Creek, ...	.....	Waste water full of culm.
Lackawanna River,...	.....	Smith Creek, ...	.....	Storrs, ...	D. L. and W. Coal Co., ...	815,552	Wet and dry, ..	.....	685,260	Mine water, ...	Mine water pumped to Lackawanna River. Slush runs to mines or to Smith Creek.	.....	Slush water full of culm.
Lackawanna River,...	.....	.....	.....	Richmond No. 3, ...	Scranton Coal Co., ...	145,443	Dry, ...	.....	.....	.....	No drainage.		
Lackawanna River,...	.....	.....	.....	Marvine No. 1, ...	D. and H. Coal Co., ...	348,042	Wet and dry, ..	.....	350,000	Mine water, ...	Slush runs to the mines. Waste water drains to Lackawanna River.		
Lackawanna River,...	28	Leggitt's Creek, ...	.....	Marvine No. 2, ...	D. and H. Coal Co., ...	.....	.....	.....	.....	.....	.....	.....	New breaker, not completed.
Lackawanna River,...	.....	Leggitt's Creek, ...	Leach Creek, ...	Cayuga, ...	D. L. and W. Coal Co., ...	233,126	Wet and dry, ..	.....	378,000	Mine water, ...	Part of slush flushed to mines. Waste and mine water drains to Leggitt's Creek.		
Lackawanna River,...	.....	.....	.....	Leggitt's Creek, ...	D. and H. Coal Co., ...	407,043	Wet and dry, ..	.....	598,750	Leggitts Creek, ...	Slush runs to mines. Waste and mine water drain to Leggitt's Creek.	.03370	
Lackawanna River,...	.....	.....	.....	Van Storch, ...	D. and H. Coal Co., ...	520,561	Wet and dry, ..	.....	628,800	Lackawanna River, ...	Clear mine water pumped direct to Lackawanna River. Slush flushed through bore holes to mines.	.04440	
Lackawanna River,...	.....	.....	.....	Clearview, ...	Peoples Coal Co., ...	40,702	Dry, ...	.....	.....	.....	No drainage.		
Lackawanna River,...	.....	.....	.....	West Ridge, ...	Scranton Coal Co., ...	94,686	Dry, ...	.....	.....	.....	No surface drainage, ...	.....	All culm is shipped away in cars. Mine water drains underground to other mines.
Lackawanna River,...	.....	.....	.....	Brisbin, ...	D. L. and W. Coal Co., ...	219,867	Wet and dry, ..	.....	466,560	Mine water, ...	Mine water to Lackawanna River. Slush and waste water flushed to mines.		
Lackawanna River,...	.....	.....	.....	Bull's Head, ...	Bull's Head Coal Co., ...	35,491	Dry, ...	.....	.....	.....	No drainage.		
Lackawanna River,...	29	.....	.....	Penna. No. 1 Plane, ...	Penna. Coal Co., ...	669,927	Wet and dry, ..	2,000	432,000	Mine water, ...	Slush flushed to mines. Waste water to slush bank, drains to No. 29 Creek.	.....	Mine water stored in pond for use in washery.
Lackawanna River,...	.....	.....	.....	Manville, ...	Operated alternately by the D. and H. and D. L. and W. Cos.	139,015	Wet and dry, ..	.....	{324,600 / 252,000}	Mine water, ...	Slush runs to mines. Waste used in cooling ashes flushed to No. 29 Creek.	.04100	
Lackawanna River,...	.....	.....	.....	Economy Washery, ...	Economy Heat, Light and Power Co.	29,115	Wet, ...	.....	.....	Lackawanna River, ...	Slush to settling tank, draining to the Lackawanna River.		
Lackawanna River,...	.....	.....	W. Branch, ...	Penna. No. 5, ...	Penna. Coal Co., ...	347,321	Wet and dry, ..	1,000	324,000	Mine water, ...	Slush and waste water flushed back to mines.		
Lackawanna River,...	.....	.....	.....	Green Ridge, ...	Green Ridge Coal Co., ...	100,137	Dry, ...	.....	.....	.....	No surface drainage.		
Lackawanna River,...	.....	.....	.....	Pine Brook, ...	Scranton Coal Co., ...	471,468	Wet and dry, ..	.....	202,500	Mine water, ...	Slush flushed to mines, ...	.....	No surface drainage from colliery found.
Lackawanna River,...	.....	.....	.....	Diamond Breaker and Washery, ...	D. L. and W. Coal Co., ...	512,641	Wet and dry, ..	.....	{336,000 / 540,000}	Mine water, ...	Most of slush flushed to mines. Some slush and mine water runs direct to Lackawanna River.		
Lackawanna River,...	.....	.....	.....	Mt. Pleasant, ...	Scranton Coal Co., ...	179,542	Wet and dry, ..	.....	99,000	Mine water, ...	Slush bank drains toward Lackawanna River.		
Lackawanna River,...	30	Roaring Brook, ...	.....	J. J. Boland, ...	J. J. Boland Coal Co., ...	.....	Dry, ...	.....	.....	.....	No drainage.		
Lackawanna River,...	.....	Roaring Brook, ...	.....	Depew, ...	Depew Coal Co., ...	.....	Dry, ...	.....	.....	.....	No surface drainage.		
Lackawanna River,...	.....	Roaring Brook, ...	.....	Spencer, ...	A. D. and F. M. Spencer Coal Co.	83,660	Wet and dry, ..	.....	175,000	Roaring Brook, ...	Slush bank drains to Roaring Brook, ...	.10000	Small breaker; only one drift.
Lackawanna River,...	.....	Roaring Brook, ...	.....	Nay Aug, ...	Nay Aug Coal Co., ...	80,990	Wet, ...	.....	200,000	Roaring Brook, ...	Slush bank draining to Roaring Brook.		
Lackawanna River,...	.....	Roaring Brook, ...	.....	Colliery No. 6, ...	No. 6 Coal Co., ...	6,781	Dry, ...	.....	.....	.....	No surface drainage.		
Lackawanna River,...	.....	Roaring Brook, ...	.....	Washery, ...	Lackawanna and Wyoming Valley R. R.	.....	Wet, ...	.....	.....	Roaring Brook, ...	Slush drains back to Roaring Brook, ...	.....	Culm is pumped out of Roaring Brook to washery. No banks or mine openings.
Lackawanna River,...	.....	.....	.....	Oxford, ...	Peoples Coal Co., ...	138,607	Wet and dry, ..	.....	144,000	Mine water, ...	All slush flushed to mines, ...	.02885	No surface drainage.
Lackawanna River,...	.....	.....	.....	Bellevne, ...	D. L. and W. Coal Co., ...	582,250	Wet and dry, ..	.....	570,000	Mine water, ...	Slush flushed into mines. Overflow mine water and overflow from slush pumps drains to Lackawanna River.	.....	Washery not working at present.
Lackawanna River,...	.....	.....	.....	Dodge, ...	D. L. and W. Coal Co., ...	293,844	Wet, ...	.....	570,000	Mine water, ...	Slush bank drains to Lackawanna River.		
Lackawanna River,...	.....	.....	.....	Bradley No. 2 Washery, ...	South Side Coal Co., ...	63,212	Wet, ...	.....	.....	Lackawanna River, ...	Slush bank drains to Lackawanna River.		
Lackawanna River,...	.....	.....	.....	Bradley No. 1 Washery, ...	South Side Coal Co., ...	.....	Wet, ...	.....	.....	Lackawanna River, ...	Slush bank drains to Lackawanna River. ..	.....	At present not working.
Lackawanna River,...	.....	.....	.....	National, ...	D. L. and W. Coal Co., ...	293,501	Wet and dry, ..	.....	273,300	Mine water, ...	Most of slush from washery annex flushed to mines. Waste water from breaker runs direct to Lackawanna River.		
Lackawanna River,...	31	Keyser's Creek, ...	.....	Capouse, ...	Scranton Coal Co., ...	218,167	Wet and dry, ..	.....	117,000	Mine water, ...	Waste water drains through ash bank to Keyser's Creek.	.....	Little water used; preparation dry except No. 2-3 buckwheat.
Lackawanna River,...	.....	Keyser's Creek, ...	.....	Hyde Park, ...	D. L. and W. Coal Co., ...	335,399	Wet and dry, ..	.....	540,000	Keyser Creek and mine water.	Most of slush flushed to mines. Waste water and part of slush direct to Keyser's Creek.		
Lackawanna River,...	.....	Keyser's Creek, ...	.....	Hampton Washery, ...	D. L. and W. Coal Co., (1912)	177,339	Wet, ...	.....	864,000	Mine water, ...	Part of slush flushed to mines. Part slush runs to Keyser's Creek.	.....	Not working at present.
Lackawanna River,...	.....	Keyser's Creek, ...	.....	Sloan, ...	D. L. and W. Coal Co., ...	424,419	Dry, ...	.....	.....	.....	No drainage.		
Lackawanna River,...	.....	Keyser's Creek, ...	.....	Continental, ...	D. L. and W. Coal Co., ...	236,299	Dry, ...	.....	.....	.....	No drainage.		
Lackawanna River,...	.....	Keyser's Creek, ...	.....	Archbald, ...	D. L. and W. Coal Co., ...	501,925	Wet and dry, ..	.....	960,000	Keyser Creek and mine water.	Some slush flushed to mines, rest of slush to waste bank, drains to Keyser's Creek.		
Lackawanna River,...	.....	Keyser's Creek, ...	.....	Holden, ...	D. L. and W. Coal Co., ...	231,090	Wet and dry, ..	.....	273,300	Mine water, ...	Slush run to mines. Waste and mine water drains to Keyser's Creek.	.....	Washery used as breaker annex.
Lackawanna River,...	.....	Keyser's Creek, ...	.....	Marion Washery, ...	Marion Coal Co., ...	.....	Wet, ...	.....	.....	Keyser Creek, ...	.....	.....	Not working, pending Boland-Archbald suit.

TABLE No. I—*Continued*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 1913 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Disposition per Ton of Output	Remarks
Lackawanna River,...	.....	Keyser's Creek, ...	.....	Taylor, ...	D. L. and W. Coal Co., ...	406,285	Wet and dry, ..	.....	570,000	Mine water, ...	Most of slush goes to mines. Some waste and mine water drains to Keyser's Creek.	.....	Washery used as breaker annex.
Lackawanna River,...	.....	.....	.....	Washery, ...	Thorne-Neal Co., ...	151,196	Wet, ...	.....	.....	Lackawanna River, ...	Slush bank drains to Lackawanna River, ...	.....	Not working.
Lackawanna River,...	32	.....	.....	New Breaker, ...	Minooka Coal Co., ...	5,071	.....	.....	.....	.....	No drainage, ...	.....	Not yet completed.
Lackawanna River,...	.....	.....	.....	Premier Washery, ...	Premier Coal Co., ...	27,566	Wet, ...	.....	.....	.....	Slush bank draining to No. 32 Creek, ...	.....	Will be abandoned in near future.
Lackawanna River,...	.....	.....	.....	Openings, ...	D. and H. Coal Co., ...	.....	.....	.....	.....	.....	.....	.....	Mine water drains to No. 32 Creek.
				Greenwood No. 2, ...	D. and H. Coal Co., ...	268,898	Wet and dry, ..	.....	495,600	Mine water, ...	Washery slush to bank, draining to Lackawanna River. Breaker waste water and mine water drain direct to Lackawanna River.	.0101	Both the streams carry much silt.
Lackawanna River,...	.....	.....	.....	Pumping Station, ...	D. and H. Coal Co., ...	.....	.....	.....	.....	.....	.....	.....	Mine water direct to Lackawanna River.
Lackawanna River,...	33	Spring Brook, ...	.....	Consolidated, ...	Penna. Coal Co., ...	165,193	Wet and dry, ..	500	216,000	One-half mine water and one-half surface water	Slush bank draining to Spring Brook, ...	.....	Washery as breaker annex.
Lackawanna River,...	.....	.....	.....	Old Forge, ...	Penna. Coal Co., ...	837,009	Wet and dry, ..	2,500	486,000	One-half mine water and one-half surface water.	Overflow mine water direct to Lackawanna River. Slush flushed to mines. Waste water direct to Lackawanna River.	.....	Washery used only as breaker annex.
Lackawanna River,...	34	Mill Brook, ...	Collins Creek, ...	Jim Dainty Opening, ...	Jim Dainty, ...	.....	Dry, ...	.....	.....	.....	.....	.....	Mining and preparation by hand. a little water used.
Lackawanna River,...	.....	Mill Brook, ...	Collins Creek, ...	C. P. Holden, ...	C. P. Holden, ...	.....	Dry, ...	.....	.....	.....	No drainage, ...	.....	Small breaker.
Lackawanna River,...	.....	Mill Brook, ...	Little Mill Brook, ...	Heidelburg No. 1, ...	L. V. Coal Co., ...	270,998	Wet and dry, ..	.....	300,000	Mine water, ...	Washery slush to slush bank, drains to Mill Brook. Waste water direct to Mill Brook.	.....	Washery as breaker annex.
Lackawanna River,...	.....	Mill Brook, ...	Little Mill Brook, ...	Washery, ...	United Coal Co., ...	.....	Wet, ...	.....	.....	Little Mill Creek, ...	.....	.....	Washing culm and rock bank.
Lackawanna River,...	.....	Mill Brook, ...	Little Mill Brook, ...	Aoca Pick up Plant, ...	Penna. Coal Co., ...	.....	Wet, ...	200	108,000	Little Mill Creek, ...	Slush runs direct to Mill Brook, ...	.....	Coal prepared at the Central Colliery.
Lackawanna River,...	.....	Mill Brook, ...	Little Mill Brook, ...	Langcliffe, ...	D. and H. Coal Co., ...	100,487	Wet and dry, ..	.....	161,700	Mine water, ...	Some slush to mines. Slush bank draining to Mill Brook.	.09510	Washery as breaker annex.
Lackawanna River,...	.....	Mill Brook, ...	.....	Ceatral, ...	Penna. Coal Co., ...	381,686	Wet and dry, ..	1,200	486,000	Mine water, ...	Slush run to mines. Waste water run direct to Mill Brook.	.....	Washery as breaker annex.
Lackawanna River,...	.....	Mill Brook, ...	.....	No. 13 Shaft, ...	Penna. Coal Co., ...	.....	.....	.....	.....	.....	.....	.....	Mine water pumped to Old Forge.
Lackawanna River,...	35	Rade Brook, ...	Pyne Creek, ...	Pyne, ...	D. L. and W. Coal Co., ...	489,737	Wet and dry, ..	.....	270,000	Surface and mine water, ...	Slush flushed to mines, ...	.....	Washery as breaker annex.
Lackawanna River,...	.....	Rade Brook, ...	St. Johns Creek, ...	Sibley, ...	Penna. Coal Co., ...	212,887	Wet and dry, ..	600	324,000	Mine water, ...	Mine water direct to St. Johns Creek. Slush bank drains to St. Johns Creek.	.....	Washery as breaker annex.
Lackawanna River,...	.....	Rade Brook, ...	St. Johns Creek, ...	Jermyn No. 1, ...	Jermyn Coal Co., ...	507,620	Wet, ...	.....	.....	Mine water, ...	Slush bank drains to St. Johns Creek.	.....	
Lackawanna River,...	.....	Rade Brook, ...	.....	Austin, ...	L. V. Coal Co., ...	13,347	.....	.....	.....	.....	Mine water direct to Rade Brook, ...	.....	Breaker gone.
Lackawanna River,...	.....	Rade Brook, ...	.....	Openings, ...	Jermyn Coal Co., ...	.....	.....	.....	.....	.....	Mine water direct to St. Johns Creek.	.....	
Lackawanna River,...	.....	.....	.....	William A., ...	L. V. Coal Co., ...	263,021	Wet and dry, ..	.....	480,000	Mine water, ...	Mine water direct to Lackawanna River. Slush bank drains to Coal Brook.	.....	Washery as breaker annex.
Lackawanna River,...	.....	.....	.....	Hallstead, ...	D. L. and W. Coal Co., ...	115,248	Wet and dry, ..	.....	387,600	Mine water, ...	Washery slush to slush bank. No apparent outlet. Waste and mine water direct to Lackawanna River.	.....	Washery as breaker annex.
Lackawanna River,...	36	Coal Brook, ...	.....	Lawrence Openings, ...	.....	.....	.....	.....	.....	.....	.....	.....	
Lackawanna River,...	37	.....	.....	Openings, ...	L. V. Coal Co., ...	.....	.....	.....	.....	.....	Mine water runs to Coal Brook, ...	.....	Breaker entirely gone.
Lackawanna River,...	38	Falling Springs Brook, ...	.....	Openings, ...	L. V. Coal Co., ...	.....	.....	.....	.....	.....	Mine water to No. 37 Creek.		
Lackawanna River,...	.....	.....	.....	Barnum, ...	Penna. Coal Co., ...	217,575	Wet and dry, ..	700	324,000	Mine water, ...	Mine water to Falling Springs Brook. Slush bank drains to Susquehanna River. Waste and mine water drain direct to Lackawanna River.		
Susquehanna River,...	39	Carpenter's Creek, ...	.....	New Schooley Shaft, ...	Penna. Coal Co., ...	.....	.....	.....	.....	.....	Mine water to Carpenter's Creek. Waste and slush flushed into mines.	.....	Coal prepared at Ewen.
Susquehanna River,...	.....	Carpenter's Creek, ...	.....	Exeter, ...	L. V. Coal Co., ...	473,297	Wet and dry, ..	.....	500,000	Mine water, ...	Excess mine water drains to Carpenter's Creek.	.....	No culm reaching any stream.
Susquehanna River,...	.....	Carpenter's Creek, ...	.....	Stevens Shaft and Washery, ...	L. V. Coal Co., ...	129,473	Wet, ...	.....	.....	.....	Mine and slush bank drainage to Carpenter's Creek.	.....	Breaker abandoned. Washery supplies boilers. Coal prepared at William A.
Susquehanaa River,...	.....	.....	.....	Breaker (Abandoned), ...	J. P. Cake, ...	.....	.....	.....	.....	.....	No drainage.		
Susquehanna River,...	.....	.....	.....	Seneca, ...	L. V. Coal Co., ...	239,514	Wet and dry, ..	.....	240,000	Mine water, ...	Waste water and slush flushed to mines, excess mine water drains to Susquehanna River.	.....	Only culm reaching Susquehanna River is washed from large culm bank.
Susquehaana River,...	.....	.....	.....	No. 9 Colliery, ...	Penna. Coal Co., ...	830,255	Wet and dry, ..	2,500	1,080,000	Mine water, ...	Slush bank draining to Mill Brook. Mine and waste water drain to Susquehanna River.	.....	Washery as breaker annex. Both the streams carry fine culm.
Susquehanna River,...	.....	.....	.....	Heidelburg No. 2 Shaft, ...	L. V. Coal Co., ...	.....	.....	.....	.....	.....	Mine water drains to pond. Used as wash water supplied by Butler Colliery.	.....	Coal prepared at Heidelburg No. 1.
Susquehanna River,...	.....	.....	.....	Butler, ...	Penna. Coal Co., ...	668,072	Wet and dry, ..	2,500	1,080,000	Mine water, ...	Waste water flushed to mines. Slush to slush bank, drains to Susquehanna River.		
Susquehanna River,...	40	.....	.....	No. 3 Shaft, ...	Penna. Coal Co., ...	.....	.....	.....	.....	.....	Mine water to Creek No. 40.		
Susquehanna River,...	41	Tompkins Creek, ...	.....	Yost, ...	Yost Mining Co., ... (1912)	12,499	.....	.....	.....	.....	Mine water drains to Tompkins Creek, ...	.....	Abandoned.
Susquehanna River,...	.....	Tompkins Creek, ...	.....	No. 4 Shaft, ...	Penna. Coal Co., ...	.....	.....	.....	.....	.....	Mine water drains to Tompkins Creek.		
Susquehanna River,...	42	.....	.....	No. 6 Colliery, ...	Penna. Coal Co., ...	627,936	Wet and dry, ..	1,900	$10,000	Mine water, ...	All slush and waste water flushed to mines. Excess mine water drains to Creek No. 42.	.....	Washery as breaker annex.
Susquehanna River,...	.....	.....	.....	Ewen, ...	Penna. Coal Co., ...	706,610	Wet and dry, ..	2,200	$10,000	No. 42 Creek and mine water.	Part of slush flushed to mines through two bore holes. Waste and rest of slush direct to Creek No. 42.	.....	Considerable culm reaches Creek No. 42.
Susquehanna River,...	.....	.....	.....	No. 14 Colliery, ...	Penna. Coal Co., ...	744,437	Wet and dry, ..	2,200	$10,000	Mine water, ...	All slush and waste water direct to Susquehanna River.	.....	Washery as breaker annex.
Susquehanna River,...	43	.....	.....	Openings, ...	Penna. Coal Co., ...	.....	.....	.....	.....	.....	Mine water direct to Creek No. 43.		

TABLE No. 1—*Continued*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 1913 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Disposition per Ton of Output	Remarks
Susquehanna River,...	44	Abraham's Creek, ...	.....	Troy, ...	Rissinger Bros. and Co., ...	40,821	Wet, ...	200	60,000	Mine and spring water, ...	Slush bank drains to Abraham's Creek. Mine and waste water to Abraham's Creek.		
Susquehanna River,...	.....	Abrahnm's Creek, ...	.....	Mt. Lookout, ...	Sterrick Creek Coal Co., ...	375,823	Wet and dry, ..	.....	200,000	Mine water, ...	All slush and waste water flushed to mines,	.....	Washery as breaker annex.
Susquehanna River,...	.....	Abraham's Creek, ...	.....	Westmoreland, ...	L. V. Coal Co., ...	226,876	Wet and dry, ..	300	300,000	Mine water, ...	Slush and part of waste water flushed to mines, rest of waste water runs to Abraham's Creek.	.....	Washery as brenker annex.
Susquehanna River,...	.....	Abrahnm's Creek, ...	.....	Maltby, ...	L. V. Coal Co., ...	354,203	Wet and dry, ..	.....	250,000	Mine water, ...	Slush and waste water flushed to mines, excess mine water to Abrahnm's Creek.	.....	Washery as breaker nnnex.
Susquehanna River,...	.....	Abraham's Creek, ...	.....	Forty Fort, ...	Sterrick Creek Coal Co., ...	261,467	Wet nnd dry, ..	700	275,000	Mine water, ...	Part of slush to mines, rest to slush baak draining to Abrahnm's Creek, excess mine water to Abrnham's Creek.		
Susquehanna River,...	45	Mill Creek, ...	East Brnnch Gardner's Creek.	Boston Openings, ...	Peuna. Coal Co., ...	.....	.....	.....	.....	.....	Mine wnter to East Branch Gardner's Creek,	.....	Coal shipped to Butler Colliery.
Susquehanna River,...	.....	Mill Creek, ...	Lampblnck Creek, ...	Pickaway, ...	McCauley Coal Co., ...	46,364	Wet and dry, ..	.....	15,000	Lampblnck Creek, ...	All slush nnd waste water direct to Lamp-black Creek.	.02750	
Susquehanna River,...	.....	Mill Creek, ...	Gardner's Creek, ...	Laflin, ...	D. nnd H. Coal Co., ...	197,062	Wet and dry, ..	.....	423,360	Mine water, ...	Slush flushed to mines. Mine water (excess) to Gardner's Creek.	.05480	
Susquehanna River,...	.....	Mill Creek, ...	Padden's Creek, ...	Keystone or Ridgewood, ...	Traders Coal Co., ...	104,508	Wet, ...	.....	.....	Mine wnter, ...	Slush run direct to Padden's Creek, ...	.....	Very black, carries much culm.
Susquehanna River,...	.....	Mill Creek, ...	.....	Central, ...	Central Coal Co., ...	.....	Wet, ...	.....	.....	Mill Creek, ...	Slush run direct to Mill Creek.		
Susquehanna River,...	.....	Mill Creek, ...	.....	Delaware, ...	D. and H. Coal Co., ...	259,254	Wet and dry, ..	.....	410,800	Mill Creek, ...	Slush flushed to mines, ...	.03180	Washery abandoned.
Susquehanna River,...	.....	Mill Creek, ...	.....	Madeira, ...	W-B Colliery Co., ...	61,320	Wet and dry, ..	.....	350,000	Mine wnter, ...	Slush run to mines.		
Susquehanna River,...	.....	Mill Creek, ...	.....	Pine Ridge, ...	D. and H. Coal Co., ...	463,310	Wet and dry, ..	.....	1,600,000	Mine water, ...	Slush flushed to mines. Wnste and excess mine water to Mill Creek.	.14290	
Susquehanna River,...	.....	Mill Creek, ...	.....	Miners Mills, ...	Miners Mills Coal Co., ...	52,565	Dry, ...	.....	.....	.....	No drainage, ...	.00700	
Susquehanna River,...	.....	Mill Creek, ...	Laurel Creek, ...	Laurel Washery, ...	D. and H. Coal Co., ...	.....	Wet, ...	.....	.....	Mine water, ...	Waste water to Laurel Creek, ...	.....	Washery merely to supply boilers.
Susquehanna River,...	.....	Mill Creek, ...	Laurel Creek, ...	Mineral Springs, ...	L. V. Coal Co., ...	302,865	Wet, ...	.....	480,000	Mine water, ...	No drainage to creek. All slush, rock and waste flushed to mines.	.....	Considered a model colliery.
Susquehanna River,...	.....	Mill Creek, ...	Laurel Creek, ...	Baltimore No. 5, ...	D. and H. Coal Co., ...	337,213	Wet and dry, ..	.....	570,000	Mine water, ...	Slush run to settling tank or to slush bank, drains to W. Branch Laurel Creek. Waste runs direct to Laurel Creek.	.15810	Washery as brenker annex.
Susquehanna River,...	.....	Mill Creek, ...	W. Branch Laurel Creek,	Baltimore No. 2 Shnft, ...	D. and H. Coal Co., ...	.....	.....	.....	.....	.....	Mine water direct to Laurel Creek		
Susquehanna River,...	.....	Mill Creek, ...	.....	Prospect, ...	L. V. Coal Co., ...	1,110,564	Wet and dry, ..	.....	1,100,000	Susquehanna River, ...	Slush bank drains to Mill Creek, and a settling tank draining to Susquehanna River.	.....	Wnshery as breaker annex. Considerable culm reaches Susquehanna River.
Susquehanna River,...	.....	.....	.....	Dorrance, ...	L. V. Coal Co., ...	533,752	Dry, ...	.....	150,000	Susquehanna River, ...	Waste wnter flushed to mines. Mine water direct to Susquehanna River.		
Susquehanna River,...	.....	.....	.....	Baltimore Tunnel, ...	D. and H. Coal Co., ...	302,673	Wet, ...	.....	648,000	Mine water, ...	Slush and rock flushed to mines. Waste water drains to Susquehanna River.	.05040	
Susquehanna River,...	.....	.....	.....	Hillman Vein, ...	W-B. Anthracite Coal Co., ...	235,882	Wet and dry, ..	.....	350,000	Mine water, ...	Slush to mines, waste water to sewer, ...	.....	Wnshery is abandoned.
Susquehanna River,...	.....	.....	.....	Hollenback No. 2, ...	L. and W. B. Coal Co., ...	472,716	Wet and dry, ..	.....	558,000	Mine water, ...	All wastes flushed to mines, ...	.....	Washery ns breaker annex.
Susquehanna River ..	.....	.....	.....	South Wilkes-Barre, ...	L. and W. B. Coal Co., ...	629,6 0	Wet nnd dry, ..	.....	438,200	Mine water, ...	Slush run to mines, ...	.....	Washery as breaker nnnex.
Susquehanna River,...	46	Tobys Creek, ...	East Branch, ...	Harry E., ...	Sterrick Creek Coal Co., ...	292,740	Wet and dry, ..	700	400,000	Mine water, ...	Waste water flushed to mines. Slush goes to slush bank, drains to E. Branch Toby's Creek.		
Susquehanna River,...	.....	Tobys Creek, ...	East Branch, ...	Pettebone, ...	D. L. nnd W. Coal Co., ...	124,147	.....	.....	.....	.....	Mine wnter to E. Brnnch of Toby's Creek, ...	.....	Coal prepared at Woodward.
Susquehanna River,...	.....	Tobys Creek, ...	.....	Louise, ...	Raub Coal Co., ...	129,002	Wet nnd dry, ..	400	216,000	Toby's Creek, ...	Slush run to mines. Waste water drains to Toby's Creek.		
Susquehanna River,...	.....	Tobys Creek, ...	.....	E. Boston No. 2 Washery, ...	E. Boston Coal Co., ...	26,695	Wet, ...	65	.....	Toby's Creek, ...	Slush flushed into E. Boston mines, or on slush bank. Wnste water runs direct to Toby's Creek.		
Susquehanna River,...	.....	Tobys Creek, ...	.....	Black Diamond, ...	Plymouth Coal Co., ...	185,918	Wet and dry,..	50	84,000	Toby's Creek and mine water.	Slush and waste water flushed to mines. Mine water run direct to Toby's Creek.		
Susquehanna River,...	.....	Tobys Creek, ...	.....	E. Boston No. 1, ...	E. Boston Coal Co., ...	159,594	Wet and dry, ..	.....	.....	Mine water, ...	Slush run to mines. Part of waste water flushed to mines, and part run to Toby's Creek.		
Susquehanna River,...	.....	Tobys Creek, ...	.....	No. 4 Colliery, ...	Kingston Coal Co., ...	670,056	Wet nnd dry, ..	200	351,000	Mine water, ...	Excess mine water to Toby's Creek. Slush and waste water to mines.		
Susquehanna River,...	.....	Tobys Creek, ...	.....	No. 2 Colliery, ...	Kingston Coal Co., ...	858,972	Wet and dry, ..	600	648,000	Mine water, ...	Slush and waste water to mines, ...	.....	Washery idle at present.
Susquehanna River,...	.....	Tobys Creek, ...	.....	Woodward, ...	D. L. and W. Coal Co., ...	923,551	Wet and dry, ..	1,400	810,000	Toby's Creek and mine water.	Waste water to settling tank, drains to Toby's Creek. Mine water to Toby's Creek. Slush run to Mines, slush bank for emergencies.		
Susquehanna River,...	47	.....	.....	Dunn, ...	Dunn Coal Co., ...	.....	Dry, ...	.....	.....	.....	.....	.....	Small operation; not working at present.
Susquehanna River,...	.....	.....	.....	Boston Washery, ...	D. and H. Coal Co., ...	.....	Wet, ...	.....	.....	Mine wnter, ...	Slush run to mines, ...	.....	Washery merely to supply boilers.
Susquehanna River,...	.....	.....	.....	Plymouth No. 3, ...	D. and H. Coal Co., ...	553,299	Wet and dry, ..	600	1,035,000	Susquehanna River, ...	Waste water drains to No. 47 Creek. Slush run to mines.	.03540	Washery as breaker annex.
Susquehanna River,...	.....	.....	.....	Plymouth No. 2, ...	D. and H. Coal Co., ...	218,899	Wet and dry, ..	.....	828,000	Susquehanna River, ...	Most of slush flushed to mines. Part of slush waste water, direct to Creek No. 47.	.09400	Washery as breaker annex.
Susquehanna River,...	.....	.....	.....	Plymouth No. 5, ...	D. and H. Coal Co., ...	450,254	Wet and dry, ..	.....	1,173,000	Susquehnnna River, ...	Waste and excess mine water, direct to Creek No. 47. Slush run to mines.	.15810	Washery as breaker nnnex; nlso supplies boilers, by washing bank.
Susquehanna River,...	.....	.....	.....	No. 1 Shaft, ...	D. and H. Coal Co., ...	.....	.....	.....	.....	.....	Mine water to No. 47 Creek.		
Susquehanna River,...	.....	.....	.....	Lance, ...	L. and W. B Coal Co., ...	280,502	Wet and dry, ..	160	431,500	Susquehanna River, ...	Slush flushed to mines. Mine and waste water to Susquehanna River.	.....	Washery as breaker annex.
Susquehanna River,...	.....	.....	.....	Dodson, ...	Plymouth Coal Co., ...	156,273	Wet and dry, ..	125	140,000	Mine water, ...	Slush bank drains to Susquehanna River. Mine water direct to Susquehanna River.		
Susquehanna River,...	48	Brown's Creek, ...	.....	Hillside, ...	Bright Coal Co., ...	19,587	Wet and dry, ..	.....	.....	Spring water, ...	Slush, waste and surface water all run direct to Brown's Creek.	.....	Water filthy, carries much culm.

TABLE No. I—*Continued*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 1913 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Disposition per Ton of Output	Remarks
Susquehanna River,...	.....	Brown's Creek, ...	.....	No. 4 Shaft, ...	D. and H. Coal Co., ...	.....	Wet, ...	.....	.....	Mine water, ...	Most of slush run to mines, rest of slush run to reservoir, draining to Brown's Creek.	.....	When reservoir cleaned culm flushed into Brown's Creek.
Susquehanna River,...	.....	Brown's Creek, ...	.....	Gaylord, ...	Kingston Coal Co., ...	243,539	Wet and dry, ..	225	230,000	Susquehanna River, ...	All rock, waste and slush flushed to mines, through three bore holes.		
Susquehanna River,...	.....	.....	.....	Parrish Washery, ...	L. and W. B. Coal Co., ...	251,298	Wet and dry, ..	.....	686,500	Susquehanna River and mine water.	Slush from washery run to mines. Overflow and waste water drains to Susquehanna River.		
Susquehanna River,...	.....	.....	.....	Nottingham, ...	L. and W. B. Coal Co., ...	795,919	Wet and dry, ..	1,000	554,000	Susquehanna River, ...	Mine water direct to Susquehanna River. Slush and waste water run to mines.	.....	Washery as breaker annex.
Susquehanna River,...	49	Coal Creek, ...	.....	Reynolds Shaft, ...	L. and W. B. Coal Co., ...	.....	.....	.....	.....	.....	Mine water to Coal Brook.		
Susquehanna River,...	50	Solomons Creek, ...	Empire Creek, ...	No. 3 Washery, ...	Red Ash Coal Co., ...	58,921	Wet, ...	.....	.....	Mine water, ...	Slush run down culm bank, drains to Empire Creek.		
Susquehanna River,...	.....	Solomons Creek, ...	Empire Creek, ...	No. 2 Breaker, ...	Red Ash Coal Co., ...	158,106	Wet and dry, ..	.....	.....	Mine water, ...	Slush bank drains to Empire Creek.		
Susquehanna River,...	.....	Solomons Creek, ...	Empire Creek, ...	Empire Washery, ...	L. and W. B. Coal Co., ...	94,160	Wet, ...	.....	885,500	Mine water, ...	Waste water drains to Empire Creek. Slush run to mines.		
Susquehanna River,...	.....	Solomons Creek, ...	Empire Creek, ...	Stanton, ...	L. and W. B. Coal Co., ...	692,259	Wet and dry, ..	.....	720,500	Mine water, ...	Slush run to mines, slush bank for emergency.		
Susquehanna River,...	.....	Solomons Creek, ...	W. Br. Empire Creek,	Franklin, ...	L. V. Coal Co., ...	316,876	Wet and dry, ..	.....	350,000	Mine water, ...	Slush to mines. Waste and mine water to W. Branch Empire Creek.		
Susquehanna River,...	.....	Solomons Creek, ...	.....	Ashley Drift, ...	L. V. Coal Co., ...	.....	.....	.....	.....	.....	Mine water to Solomons Creek.		
Susquehanna River,...	.....	Solomons Creek, ...	Preston Creek, ...	Maxwell No. 20, ...	L. and W. B. Coal Co., ...	622,566	Wet and dry, ..	.....	642,900	Mine water, ...	Excess mine water to Preston Creek. All slush and waste flushed to mines.		
Susquehanna River,...	.....	Solomons Creek, ...	.....	Buttonwood Washery, ...	L. and W. B. Coal Co., ...	117,941	Wet, ...	.....	543,500	Mine water, ...	Mine and waste water run to Solomons Creek. Slush flushed to mines.	.....	New breaker not yet finished.
Susquehanna River,...	51	.....	.....	Sugar Notch No. 9, ...	L. and W. B. Coal Co., ...	313,036	Wet, ...	.....	727,000	Mine water, ...	Excess mine water to No. 51 Creek. Slush runs to mines. Waste water to slush hank, drains to No. 51 Creek.		
Susquehanna River,...	.....	.....	.....	Hadleigh, ...	Pittston Coal Mining Co., ...	33,282	Wet, ...	.....	.....	Mine water, ...	Mine water drains to No. 51 Creek. Slush bank drains to mines and to No. 51 Creek.		
Susquehanna River,...	.....	.....	.....	Loomis, ...	D. L. and W. Coal Co., ...	74,865	.....	.....	.....	Mine water, ...	Mine water to No. 51 Creek, ...	.....	New breaker not yet finished.
Susquehanna River,...	52	Warrior Creek, ...	.....	Warrior Run Washery, ...	L. V. Coal Co., ...	.....	.....	.....	.....	.....	Mine water to No. 52 Creek, ...	.....	Washery abandoned.
Susquehanna River,...	.....	Warrior Creek, ...	.....	Truesdale, ...	D. L. and W. Coal Co., ...	1,121,323	Wet and dry, ..	.....	1,080,000	Mines and Warrior Creek,....	Waste water drains to Warrior Creek. Slush pumped to slush bank, drains to Warrior Creek.	.....	Washery as breaker annex.
Susquehanna River,...	.....	Warrior Creek, ...	Bliss Branch, ...	Bliss, ...	D. L. and W. Coal Co., ...	473,580	Wet and dry, ..	.....	810,000	Mine water, ...	Waste water direct to Bliss Branch. Slush bank drains to Bliss Branch. Mine water direct to Bliss Branch.		
Susquehanna River,...	.....	Warrior Creek, ...	Bliss Branch, ...	Auchincloss, ...	D. L. and W. Coal Co., ...	235,609	Breaker, dry, .. Washery, Wet,	.....	540,000	Bliss Branch and mines, ..	Slush to settling tank or slush bank. Overflow to Bliss Branch of Warrior Creek.	.....	Washery as breaker annex.
Susquehanna River,...	53	.....	.....	Avondale, ...	D. L. and W. Coal Co., ...	156,216	Wet and dry, ..	80	324,000	No. 53 Creek and mine water.	Slush and waste water to mines. Mine water runs to No. 53 Creek.	.....	Washery idle at present.
Susquehanna River,...	.....	.....	.....	Chauncey, ...	G. F. Lee and Co., ...	111,905	Wet and dry,..	260	.....	No. 53 Creek, ...	Waste water drains to No. 53 Creek. Slush to slush bank, drains to No. 53 Creek.		
Susquehanna River,...	.....	.....	.....	West Nanticoke, ...	W. Nanticoke Coal Co., ...	35,978	.....	.....	.....	.....	No drainage, ...	.....	Coal prepared at No. 5 Susquehanna Coal Co.
Susquehanna River,...	54	Newport Creek, ...	N. Br. Newport Creek,	Glen Lyon No. 5, ...	Susquehanna Coal Co., ...	634,237	Wet and dry, ..	1,200	629,067	Mine water, ...	Mine water to N. Branch Newport Creek. Slush to settling tanks, draining to N. Branch Newport Creek.	.00610	Culm in large quantities gets to N. Branch Newport Creek.
Susquehanna River,...	.....	Newport Creek, ...	N. Br. Newport Creek,	Stearns Shaft, ...	Susquehanna Coal Co., ...	.....	.....	.....	.....	.....	Mine water to N. Branch Newport Creek,	.....	Coal prepared at No. 5 colliery.
Susquehanna River,...	.....	Newport Creek, ...	N. Br. Newport Creek,	Nanticoke Washery, ...	Susquehanna Coal Co., ...	145,830	Wet, ...	760	1,063,578	Newport Creek and mine water.	Slush bank drains to N. Branch Newport Creek. Waste water direct to N. Branch Newport Creek.	.00810	
Susquehanna River,...	.....	Newport Creek, ...	S. Br. Newport Creek,	No. 3 Slope, ...	L. and W. B. Coal Co., ...	.....	.....	.....	.....	.....	Mine water to S. Branch Newport Creek.		
Susquehanna River,...	.....	Newport Creek, ...	S. Br. Newport Creek,	Wanamie No. 18, ...	L. and W. B. Coal Co., ...	556,872	Wet and dry, ..	.....	542,600	Mine water, ...	Waste and mine water direct to S. Branch Newport Creek. Slush run to mines, slush bank for emergencies.		
Susquehanna River,...	.....	Newport Creek, ...	S. Br. Newport Creek,	Alden, ...	Alden Coal Co., ...	301,488	Wet and dry, ..	100	313,344	Mine water, ...	Part of slush run to mine, rest to slush banks which drain to S. Branch Newport Creek. Mine water to S. Branch Newport Creek.		
Susquehanna River,...	.....	Newport Creek, ...	S. Br. Newport Creek,	No. 7 Colliery, ...	Susquehanna Coal Co., ...	410,799	Wet and dry, ..	500	648,819	Mine water and the S. Branch Newport Creek.	Slush run to slush bank, draining to Newport Creek. Waste and mine water direct to S. Branch Newport Creek.	.00140	Lots of culm reaches Newport Creek.
Susquehanna River,...	.....	Newport Creek, ...	.....	No. 5 Colliery, ...	Susquehanna Coal Co., ...	488,251	Wet and dry, ..	.....	667,800	Mine water, ...	Slush, waste and mine water all go to Newport Creek.	.00140	Streams carry much culm to Newport Creek.
Susquehanna River,...	55	Shickshinny Creek, ...	Penna. Canal, ...	Salem, ...	E. S. Stackhouse Coal Co., ...	47,091	Wet and dry, ..	120	270,000	Spring and mine water.	Slush, waste and mine water drain to Penna. Canal.		
Susquehanaa River,...	56	Black Creek, ...	.....	Lee's Shaft, ...	W. End Coal Co., ...	.....	.....	.....	.....	.....	Mine water direct to Black Creek.		
Susquehanna River,...	.....	Black Creek, ...	.....	West End, ...	W. End Coal Co., ...	631,255	Wet and dry, ..	1,300	1,485,000	Susquehanna River, ...	Mine and waste water direct to Susquehanna River. Slush bank drains to Black Creek.	.....	Considerable fine culm reaches Susquehanna River.
Susquehanna River,...	57	Nescopeck Creek, ...	Big Black Creek, ...	Eckley Washery, ...	L. V. Coal Co., ...	42,418	Wet, ...	.....	250,000	Mine water, ...	Slush bank, drainage from which is source of Big Black Creek.		
Susquehanna River,...	.....	Nescopeck Creek, ...	Big Black Creek, Cross Creek.	Drifton, ...	L. V. Coal Co., ...	366,613	Wet, ...	1,300	1,250,000	Mine water, ...	Mine and waste water direct to Cross Creek. Double settling tanks drain to Cross Creek.		
Susquehanna River,...	.....	Nescopeck Creek, ...	Big Black Creek, Cross Creek.	Highland No. 5, ...	G. B. Markle and Co., ...	399,219	Wet, ...	.....	918,000	Mine water, ...	Slush runs direct to Cross Creek, ...	.00500	
Susquehanaa River,...	.....	Nescopeck Creek, ...	Big Black Creek, ...	Jeddo No. 4, ...	G. B. Markle and Co., ...	428,981	Wet, ...	.....	1,458,000	Mine water, ...	Excess mine water goes through Jeddo Tunnel. Slush to mines, waste water to Big Black Creek.	.02600	

TABLE No. 1 —*Continued*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 1913 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Disposition per Ton of Output	Remarks
Susquehanna River,		Nescopeck Creek,	Big Black Creek,	Jeddo No. 7,	G. B. Markle and Co.,	318,858	Wet,	1,000	1,170,000	Mine water,	Settling tank drains to Big Black Creek,	.01200	
Susquehanna River,		Nescopeck Creek,	Big Black Creek, Lattimer Canal,	Lattimer No. 4,	Pardee Bros. and Co.,	637,561	Wet and dry,	1,730	612,000	Lattimer Canal,	Settling tank draining to Lattimer Canal. Waste and mine water direct to Lattimer Canal.		
Susquehanna River,		Nescopeck Creek,	Big Black Creek, Lattimer Canal,	Lattimer No. 3 Washery,	Pardee Bros. and Co.,		Wet,	160	459,000	Lattimer Canal,	Settling tank draining to Lattimer Canal. Waste water direct to Lattimer Canal.		
Susquehanna River,		Nescopeck Creek,	Big Black Creek, Lattimer Canal,	Harleigh,	Harleigh-Brookwood Coal Co.,	109,963	Wet,	300	378,000	Mine water.			
Susquehanna River,		Nescopeck Creek,	Big Black Creek, Cranberry Creek,	Hazleton No. 1,	L. V. Coal Co.,	294,043	Wet,		850,000	Mine water,	Slush bank drains to Cranberry Creek. Mine and waste water direct to Cranberry Creek.		Slush bank not efficient; much culm carried into Cranberry Creek.
Susquehanna River,		Nescopeck Creek,	Big Black Creek, Cranberry Creek,	Harwood,	Harwood Coal Co.,	171,510	Wet,			Mine water,	Waste and mine water direct to Eagle Run. Slush bank drains to Eagle Run.		
Susquehanna River,		Nescopeck Creek,	Big Black Creek, Cranberry Creek.	Cranberry,	A. Pardee and Co.,	586,597	Wet,	2,000	1,000,000	Mine water,	Mine water direct to Cranberry Creek. Settling tank draining to Cranberry Creek.		
Susquehanna River,		Nescopeck Creek,	Big Black Creek,	Black Ridge,	Hazle Mountain Coal Co.,	97,188	Wet,	400	422,000	Mine water,	Slush bank drains to Big Black Creek,	.00800	
Susquehanna River,		Nescopeck Creek,	Big Black Creek,	Tomhicken Shaft,	L. V. Coal Co.,						Mine water direct to Big Black Creek,		Colliery abandoned; coal prepared at Hazleton Shaft.
Susquehanna River,		Nescopeck Creek,	Big Black Creek,	Derringer Shaft,	L. V. Coal Co.,	269,768					Mine water direct to Big Black Creek,		Colliery abandoned; coal prepared at Hazleton Shaft.
Susquehanna River,		Nescopeck Creek,	Big Black Creek,	Slope No. 5,	Hazle Mountain Coal Co.,						Mine water to Big Black Creek,		Coal taken to Black Ridge Colliery.
Susquehanna River,		Nescopeck Creek,	Big Black Creek,	Gowan Shaft,	L. V. Coal Co.,						Mine water direct to Big Black Creek,		Colliery abandoned; coal prepared at Hazleton Shaft.
Susquehanna River,	58	Catawissa Creek,		Spring Brook Washery,	L. V. Coal Co.,	8,689	Wet,	200	270,000	Mine water,	Waste and mine water to Catawissa Creek. Slush runs into stripping, and there is no outlet.		
Susquehanna River,		Catawissa Creek,		Audenreid No. 4,	L. and W. B. Coal Co.,	471,215	Wet,	1,500	919,000	Mine water,	Waste and Mine water direct to Catawissa Creek. Slush bank drains to Catawissa Creek.		
Susquehanna River,		Catawissa Creek,		Honey Brook No. 5,	L. and W. B. Coal Co.,	330,527	Wet,	1,450	727,000	Mine water,	Waste water direct to Catawissa Creek, slush to stripping, draining to mines.		
Susquehanna River,		Catawissa Creek,	Hunkidori Creek,	No. 20 Slope,	L. and W. B. Coal Co.,						Mine water to Hunkidori Creek,		
Susquehanna River,		Catawissa Creek,	Beaver Brook,	Benver Brook,	C. M. Dodson and Co.,	393,325	Wet,	1,200	1,420,740	Mine water,	Excess mine and waste water direct to Beaver Brook. Slush bank drains to Benver Brook.	.00400	
Susquehanna River,		Catawissa Creek,	Tomhicken Creek,	Oneida Slope,	L. V. Coal Co.,	267,592					Mine water to Tomhicken Creek,		Coal prepared at Jeanesville Colliery.
Susquehanna River,		Catawissa Creek,	Scotch Run,	McCauley Mt.,	Beaver Valley Coal Co.,	6,025	Wet,			Scotch Run and mine water,	Slush to settling tanks,		Breaker and tanks being constructed, not working yet.
Susquehanna River,	59	Shamokin Creek,	North Branch,	Midvalley No. 2,	Midvalley Coal Co.,	304,867	Wet,	1,000	900,000	Mine water,	Mine and waste water are source of North Branch. Slush bank drainlug to North Branch of Shamokin Creek.	.01500	
Susquehanna River,		Shamokin Creek,	North Branch,	Richards Colliery,	Susquehanna Coal Co.,	339,364	Wet and dry,	1,100	952,562	Mine water,	Mine and waste water to North Branch of Shamokin Creek. Slush to mud elevators draining to North Branch of Shamokin Creek.	.03950	
Susquehanna River,		Shamokin Creek,	North Branch,	Pennsylvania Colliery,	Susquehanna Coal Co.,	401,329	Wet and dry,	750	1,111,074	Mine water,	Mine and waste water to North Branch of Shamokin Creek. Slush to mud elevators draining to North Branch of Shamokin Creek.	.02120	
Susquehanna River,		Shamokin Creek,	Middle Branch,	Snyre,	L. V. Coal Co.,	333,719	Wet,	1,200	900,000	Mine water,	Mine and waste water to Middle Branch Shamokin Creek. Mud elevators draining to Middle Branch Shamokin Creek.		
Susquehanna River,		Shamokin Creek,	South Branch,	Reliance,	P. and R. C. and I. Co.,	225,239	Wet,	800		Mine water,	Mine water to Shamokin Creek. Slush to Mines and slush bank draining to Shamokin Creek.		
Susquehanna River,		Shamokin Creek,	Locust Creek,	Locust Spring,	P. and R. C. and I. Co.,	614,291	Wet,	2,100	2,700,000	Mine water,	Excess mine and waste water direct to Locust Creek. Slush to mud elevators draining to Locust Creek.		
Susquehanna River,		Shamokin Creek,	Locust Creek,	Locust Spring Washery,	P. and R. C. and I. Co.,		Wet,			Mine water,			Shut down since 1912.
Susquehanna River,		Shamokin Creek,	Locust Creek,	Alaska,	P. and R. C. and I. Co.,	296,736	Wet,	1,100	1,080,000	Mine water,	Waste and mine water to Locust Creek. Slush runs to mines.		
Susquehanna River,		Shamokin Creek,	Excelsior Creek,	Enterprise Washery,	Enterprise Coal Co.,	173,682	Wet,	250	640,900	Mine and spring water,	Slush to settling tank, drains into mines. Mine and waste water all drains to mines.	.05200	Breaker idle because of mine fire.
Susquehanna River,		Shamokin Creek,		Corbin,	Excelsior Coal Co.,	226,784	Wet,	650	270,000	Mine water,	Waste and mine water direct to Shamokin Creek. Slush to mud elevators drains to Shamokin Creek.		
Susquehanna River,		Shamokin Creek,	Quaker Run,	Greenough,	Greenough Red Ash Coal Co.,	265,578	Wet and dry,	500	600,000	Mine water,	Slush to slush bank draining to Quaker Run. Waste and mine water direct to Quaker Run.		
Susquehanna River,		Shamokin Creek,	Quaker Run,	Scott,	Susquehanna Coal Co.,	305,566	Wet and dry,	300	648,000	Mine water,	Waste and mine water direct to Quaker Run. Slush to slush bank draining to Quaker Run.	.01850	Large amount of culm reaching the Run.
Susquehanna River,		Shamokin Creek,		Buck Ridge,	Buck Ridge Coal Mining Co.,	115,267	Wet and dry,	338	800,000	Mine water,	Mine and waste water to Shamokin Creek. Slush either to mines or to slush bank.	.02000	
Susquehanna River,		Shamokin Creek,		Big Mountain openings,	P. and R. C. and I. Co.,	361,265					Mine water to Shamokin Creek,		Coal prepared at Henry Clay Colliery.
Susquehanna River,		Shamokin Creek,		Henry Clay,	P. and R. C. and I. Co.,		Wet,	1,150	702,000	Mine water,	Waste and mine water to Shamokin Creek. Slush to mud elevators, then to slush bank.		
Susquehanna River,		Shamokin Creek,		Bergen-Ryan,	Bergen-Rynn Coal Co.,		Dry,				Mine water to Shamokin Creek.		New operation.
Susquehanna River,		Shamokin Creek,		Natalie,	Colonial Collieries Co.,	267,725	Wet,		600,000	Mine water,	Waste water and slush to slush bank, drains to Coal Run.	.01000	
Susquehanna River,		Shamokin Creek,	Coal Run,	Hickory Ridge,	Susquehannan Coal Co.,	301,567	Wet,	1,200	1,411,038	Coal Run and mine water,	Mine water pumped to Quaker Run. Slush and waste water to slush bank, draining to Coal Run.	.03920	

TABLE No. I—*Continued*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 19.3 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water Per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Disposition Per Ton of Output	Remarks
Susquehanaa River.		Shamokin Creek,	Coal Run,	Hickory Swamp Washery,	Susquehanna Coal Co.,	43,017	Wet,	160	285,120	Mine water,	Slush to slush bank, draining to Coal Run.	.05040	
Susquehanna River.		Shamokin Creek,	Coal Run,	Colbert,	Shipman Coal Co.,	174,130	Wet,	700	378,000	Mine water,	Slush to slush bank, draining to Coal Run.	.06510	
Susquehanna River.		Shamokin Creek,	Coal Run,	Lake Fidler,	Susquehanna Coal Co.,	192,964	Wet,	700	277,200	Mine water,	Slush bank drains to Coal Run.		
Susquehanna River.		Shamokin Creek,	Carbon Creek,	Bear Valley,	P. and R. C. and I. Co.,	278,133	Wet,	1,200		Mine water,	Mine and waste water direct to Carbon Creek. Slush to settling tanks. Mud elevators, then to slush bank.		
Susquehaaa River.		Shamokin Creek,	Carbon Creek,	Sterling openings,	P. and R. C. and I. Co.,	427,720					Mine water direct to Carbon Creek,		Coal prepared at Burnside Colliery.
Susquehanna River.		Shamokin Creek,	Carbon Creek,	Burnside,	P. and R. C. and I. Co.,		Wet and dry,..	900	500,000	Mine water,	Mine and waste water direct to Carbon Creek. Slush to slush bank, draining to Carbon Creek.		
Susquehanna River.		Shamokin Creek,		Cameron,	Susquehanna Coal Co.,	411,434	Wet,	1,550	973,252	Mine water,	Slush to and elevators. Waste and mine water direct to Shamokin Creek.	.02900	
Susquehanaa River.	60	Mahanoy Creek,	South Branch,	Buck Mountain,	L. V. Coal Co.,	514,020	Wet,	1,000	600,000	Mine water,	Slush to mines. Waste water to South Branch of Mahanoy Creek.		
Susquehanna River.		Mahanoy Creek,	Middle Branch,	Primrose,	L. V. Coal Co.,	138,058					Mine water to Middle Branch of Mahanoy Creek.		Coal prepared at Park No. 2.
Susquehaana River.		Mahanoy Creek,	North Branch,	Park No. 2,	L. V. Coal Co.,	335,208	Wet,	1,825	1,250,000	Mine and spring water.	Slush to slush bank, draining to Mahanoy Creek. Waste water to mud elevators draining to Mahanoy Creek.		North Branch full of culm below slush bank.
Susquehanna River.		Mahanoy Creek,	North Branch,	Springdale Washery,	L. V. Coal Co.,		Wet,	700	260,000	Mine water,	Settling tank and mud elevators drains to mines.		New washery.
Susqaehanaa River.		Mahanoy Creek,	North Branch,	North Mahanoy,	P. and R. C. and I. Co.,	416,590	Wet,	1,500	1,782,000	Mine water,	Waste water direct to Mahanoy Creek. Slush to settling tank and mud elevators draining to Mahanoy Creek.		
Susquehanna River.		Mahanoy Creek,	North Branch,	Mahanoy City,	P. and R. C. and I. Co.,	294,379	Wet,	950	900,000	Mine water,	Settling tank and mud elevators drains to Mahanoy Creek.		
Susquehanna River.		Mahanoy Creek,		Tunnel Ridge,	P. and R. C. and I. Co.,	201,470	Wet,	500	931,500	Mine water,	Settling tank and mud elevators drains to Mahanoy Creek.		
Susquehaana River.		Mahanoy Creek,	Waste House Run,	Knickerbocker Shaft,	P. and R. C. and I. Co.,	161,190					Mine water to Waste House Run,		Coal prepared at Ellangowan.
Susquehanaa River.		Mahanoy Creek,	Waste House Run,	Ellangowan,	P. and R. C. and I. Co.,	384,718	Wet,	2,000	675,000	Mine water,	Slush to settling tank and screen. Drains to Waste House Run. Mine and waste water direct to Waste House Run.		
Susquehaana River.		Mahanoy Creek,	Waste House Run,	Maple Hill,	P. and R. C. and I. Co.,	808,935	Wet,	2,450	3,240,000	Mine water,	Mine and waste water direct to Waste House Run. Slush to settling tank and mud elevators drains to Waste House Run.		
Susquehanaa River.		Mahanoy Creek,	Waste House Run,	St. Nicholas and Suffolk,	P. and R. C. and I. Co.,	589,386	Wet,	1,900	2,700,000	Mine water,	Waste and mine water drain to Waste House Run. Slush to settling tanks and mud elevators.		
Susquehaana River.		Mahanoy Creek,		Boston Run,	P. and R. C. and I. Co.,	232,129	Wet,	600	259,200	Mine water,	Waste and mine water direct to Mahanoy Creek. Settling tank, screen and slush bank.		
Susquehaana River.		Mahanoy Creek,		Gilberton,	P. and R. C. and I. Co.,	106,691	Wet,	400	810,000	Mine water,	Settling tank, then to slush bank, draining to Mahanoy Creek.		
Susquehanna River.		Mahanoy Creek,		Draper,	P. and R. C. and I. Co.,	216,665	Wet,	800	486,000	Mine water,	Waste and mine water direct to Mahanoy Creek. Slush to settling tank, drains to Mahanoy Creek.		
Susquehaana River.		Mahanoy Creek,		Stanton,	Harleigh-Brookwood Coal Co.,	173,778	Wet,	1,000	2,000,000	Mine water,	Part of slush pumped to slush banks, and part to Mahanoy Creek.		
Susquehaana River.		Mahanoy Creek,		Bear Ridge No. 2 Shaft,	Harleigh-Brookwood Coal Co.,	24,907					Mine water direct to Mahanoy Creek.		Making preparations for new breaker.
Susquehaana River.		Mahanoy Creek,		New Breaker,	Madeira-Hill and Co.,								Breaker is under construction. Capacity will be 3,500 a day.
Susquehanna River.		Mahanoy Creek,		Girard,	McTurk Coal Co.,	90,266					Slush bank drains to Mahanoy Creek. Mine water direct to Mahanoy Creek.		Not working at present. Old breaker being remodeled.
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	Indian Ridge openings,	P. and R. C. and I. Co.,						Mine water to Lower Rausch Creek.		
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek, Kehley's Run.	Kehley's Run,	Thomas Colliery Co.,	288,110	Wet,	1,200	432,000	Mine water,	Slush to slush bank. Waste water to settling tank.		
Susquehaaaa River.		Mahanoy Creek,	Shenandoah Creek,	Plank Ridge Washery,	P. and R. C. and I. Co.,						No drainage,		Idle since 1912.
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	Shenandoah City,	P. and R. C. and I. Co.,	311,329	Wet,	2,000	1,030,000	Mine water and Shenandoah Creek.	Mud elevators and settling tank for slush.		
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	Cambridge,	Cambridge Coal Co.,	78,724	Wet,	350	500,000	Mine water and Shenandoah Creek.	Part of slush is flushed to the mines. Most of slush runs directly to Shenandoah Creek.	.02000	
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	West Shenandoah,	P. and R. C. and I. Co.,	511,139	Wet,	2,000		Mine water and Shenandoah Creek.	Waste and mine water to Shenandoah Creek. Slush to settling tank and mud elevators.		Considerable culm reaching Shenandoah Creek.
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	Kohinoor Shaft,	P. and R. C. and I. Co.,						No drainage,		All coal shipped to West Shenandoah Colliery.
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	Hudson Washery,	H. H. Smith and Co.,	69,705	Wet,	300		Shenandoah Creek.	All slush runs to Shenandoah Creek.		
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	Weston,	Locust Mountain Coal Co.,	2,500	Wet and dry,..	500	810,000	Mine water,	Mine and waste water direct to Shenandoah Creek. Slush to settling tank and mud elevators, drains to Shenandoah Creek.		
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	Oxford Washery,	Oxford Coal Co.,	20,350					No drainage,		Washery idle for some time.
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	Packer No. 4,	L. V. Coal Co.,	189,499	Wet,	3,000	2,000,000	Mine and creek water.	Slush and waste water to slush bank. Draining to Shenandoah Creek.		
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek,	William Penn,	Susquehanna Coal Co.,	327,072	Wet and dry,..	1,000	510,000	Mine water,	Waste and mine water to Shenandoah Creek. Slush to slush bank, drains to Shenandoah Creek.	.01900	
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek, Lost Creek.	Packer No. 2 Shaft,	L. V. Coal Co.,	159,010					Mine water to Shenandoah Creek.		

TABLE No. I—*Continued*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 1913 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water Per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Disposition Per Ton of Output	Remarks
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek, Girard Creek.	Girard Mammoth,	Girard Mammoth Coal Co.,	212,756	Wet,	800	630,000	Mine water,	All slush, waste and mine water direct to Girard Creek.		Creek full of culm.
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek.	Hammond,	P. and R. C. and I. Co.,	375,319	Wet,	1,200	2,100,000	Mine water,	Slush to mud elevators. Waste and mine water to Girard Creek.		Some culm reaches Girard Creek.
Susquehanna River.		Mahanoy Creek,	Shenandoah Creek.	Packer No. 5,	L. V. Coal Co.,	595,669					Mine water to Shenandoah Creek,		New steel breaker under construction.
Susquehanna River.		Mahanoy Creek,	Big Mine Run.	Centralia,	L. V. Coal Co.,	437,308	Wet,		1,000,000	Mine water,	Slush to slush bank, draining to Big Mine Run,		Considerable culm reaching Big Mine Run.
Susquehanna River.		Mahanoy Creek,	Big Mine Run.	Bast,	P. and R. C. and I. Co.,	269,662	Wet,	900	1,620,000	Mine water,	Settling tank and mud elevators,		A little culm reaching Big Mine Run.
Susquehanna River.		Mahanoy Creek,	Locust Run.	Locust Run openings,	L. V. Coal Co.,						Mine water to Locust Run,		Coal shipped to Centralia Colliery.
Susquehanna River.		Mahanoy Creek,	Big Run.	Potts,	P. and R. C. and I. Co.,	336,307	Wet,	1 000	965,235	Mine water,	Mine and waste water to Middle Branch of Big Run. Slush bank drains to Highlanders Run. Mud elevators for emergencies.		Slush bank believed to be more efficient than mud elevators.
Susquehanna River.		Mahanoy Creek,	Zerbe Run,	North Franklin,	P. and R. C. and I. Co.,	390,624	Wet,	1,600		Mine water,	Slush to settling tank and slush bank.		
Susquehanna River.		Mahanoy Creek,	Zerbe Run,	Kathrine,	Trevorton Colliery Co.,	112,162	Wet,		200,000	Mine water and Mahnnoy Creek.	Settling tank or slush bank draining to Zerbe Run.		
Susquehanna River.	61	Mahantango Creek,	West Branch of Rausch Creek.	Williamstown No. 2 Shaft,	Susquehanna Coal Co.,						Mine water to West Branch Rausch Creek,		Coal taken through tunnel to Williamstown Colliery.
Susquehanna River.		Mahantango Creek,	Rausch Creek,	Valley View openings,	P. and R. C. and I. Co.,	179					No drainage,		Coal taken through tunnel to W. Brookside Colliery.
Susquehanna River.	62	Wiconisco Creek,		East Brookside openings,	P. and R. C. and I. Co.,						Mine water draining to Wiconisco Creek,		Coal prepared nt W. Brookside Colliery.
Susquehanna River.		Wiconisco Creek,		West Brookside,	P. and R. C. and I. Co.,	312,882	Wet,	1,000	864,000	Mine water,	Settling box and slush bank draining to Wiconisco Creek.		
Susquehanna River.		Wiconisco Creek,		Williamstown Breaker,	Susquehanna Coal Co.,	379,634	Wet,	1,300	875,000	Mine water and Wiconisco Creek.	Slush to large slush bank. Draining to Wiconisco Creek.	.01160	
Susquehanna River.		Wiconisco Creek,		Williamstown Washery,	Susquehanna Coal Co.,	114,977	Wet,	175	1,250,000	Mine water and Wiconisco Creek.	Slush to large slush bank. Draining to Wiconisco Creek.	.15820	
Susquehanna River.		Wiconisco Creek,		Short Mountain Breaker,	Susquehanna Coal Co.,	372,375	Wet,	1,100	750,000	Mine water,	Settling tank and slush bank. Draining to Wiconisco Creek.	.00560	
Susquehanna River.		Wiconisco Creek,		Short Mountain Washery,	Susquehanna Coal Co.,	79,684	Wet,	200	1,500,000	Mine water,	Settling tank and slush bank. Draining to Wiconisco Creek.	.05660	
Susquehanna River.	63	Swatara Creek,	Panther Creek,	Blackwood,	L. V. Coal Co.,	288,841	Wet,	1,000	500,000	Mine water,	Waste water to settling tank, drains to Panther Creek. Slush to slush bank, drains to Panther Creek.		
Susquehanna River.		Swatara Creek,	Middle Creek,	Middle Creek Washery,	P. and R. C. and I. Co.,						Mine water to Middle Creek,		Idle at present.
Susquehanna River.		Swatara Creek,	Good Spring Creek,	Good Spring,	P. and R. C. and I. Co.,	340,346	Wet,	1,000	618,400	Mine water,	Waste and mine water direct to Good Spring Creek. Slush to slush bank, drains to Good Spring Creek.		Carries fine culm to creek.
Susquehanna River.		Swatara Creek,	Good Spring Creek,	No. 3 Slope,	P. and R. C. and I. Co.,						Mine water to Good Spring Creek,		Coal taken to Good Spring Colliery.
Susquehanna River.		Swatara Creek,	Lower Rausch Creek,	Pumping station,	P. and R. C. and I. Co.,						Mine water of Lower Rausch Cr k.		
Susquehanna River.		Swatara Creek,	Lower Rausch Creek,	Rausch Creek Washery.	P. and R. C. and I. Co.,		Wet,				Mine water to Lower Rausch Creek,		Not working at present.
Susquehanna River.		Swatara Creek,	Lorberry Creek,	Lincoln,	P. and R. C. and I. Co.,	527,989	Wet,	1,700	1,458,000	Mine water,	Slush to slush bank, draining to Stump's Run. Waste and mine water direct to Lorberry Creek.		Fine culm reaching Stump's Run.
Lehigh River.	64	Pond Creek,		Upper Lehigh,	Upper Lehigh Coal Co.,	171,510	Wet,		700,000	Mine water.	Waste water to bank, drains to Pond Creek. Slush runs to a settling tank, draining to Pond Creek.	.01500	Large amount of culm reaches Pond Creek.
Lehigh River.		Pond Creek,		Old Breaker,	Pond Creek Coal Co.,						Mines flooded by Pond Creek,		Not working. Breuker would drain direct to creek.
Lehigh River.		Pond Creek,		Brandmaier,	Fred. Brandmaier,						Mines flooded by Pond Creek,		Not working.
Lehigh River.		Pond Creek,		Pond Creek,	Pond Creek Coal Co.,						No drainage,		Coal is prepared at Harleigh Colliery.
Lehigh River.		Pond Creek,	Sandy Run,	Highland No. 2,	G. B. Markle and Co.,	304,233	Wet,	850	918,000	Mine water,	Slush bank for slush, drains to Sandy Run.	.00800	Carries considerable culm to the run.
Lehigh River.		Pond Creek,	Sandy Run.	Sandy Run.	M. S. Kemmerer and Co.,	98,931	Wet,	350	972,000	Mine water.	Waste and mine water drains to Sandy Run. Slush runs over 1/16 inch screen, draining to Sandy Run.		
Lehigh River.				Old Buck Mountain openings,	L. V. Coal Co.,						Mine water direct to Laurel Run.		
Lehigh River.	65	Laurel Run.		Hazleton Shaft.	L. V. Coal Co.,	396,262	Wet,	3,000	2,000 000	Mine water,	Slush to settling tank and mud elevators, drains to Hazle Creek.		
Lehigh River.	66	Quakake Creek,	Hazle Creek,	Hazle Brook,	J. S. Wentz and Co.,	142,260	Wet,	500	600,000	Mine water,	Waste water and slush to slush bank, draining to Hazle Creek.	.01500	
Lehigh River.		Quakake Creek,	Hazle Creek,	Jeanesville (or Spring Mountain).	L. V. Coal Co.,	365,958	Wet,	2,200	1,000,000	Mine water,	Slush run to settling tanks, draining to Beaver Creek. Waste and mine water direct to Beaver Creek.		
Lehigh River.		Quakake Creek,	Beaver Creek,	Coleraine,	A. S. Van Wickle Estate,	284,773	Wet,	800	756,000	Mine water,	All slush and waste water run direct to Beaver Creek.	.00400	
Lehigh River.		Quakake Creek,	Beaver Creek,	Beaver Meadow,	L. V. Coal Co.,	257,711	Wet,	1,000	400,000	Mine water,	Slush to old stripping, draining to mines. Mine and waste water to slush bank, draining to Beaver Creek.		
Lehigh River.		Quakake Creek,	Beaver Creek,	Evans,	Evans Colliery Co.,	30,189	Wet,	100	250,000	Mine water,	Slush and waste wnter to slush bank, draining to Beaver Creek.		
Lehigh River.		Quakake Creek,	Beaver Creek,	Penn Forest,	Penn Forest Coal Co.,					Beaver Creek,	No drainage at present,		New breaker being built. Not yet operating.
Lehigh River.	67	Nesquehoning Creek,		New Hanto Washery,	L. C. and N. Co.,	215,326	Wet,	670	408,240	Nesquehoning Creek.	Waste and mine water direct to Nesquehoning Creek. Slush to slush bank, draining to Nesquehoning Creek.	.00680	

TABLE No. I—*Continued*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 1913 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water Per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Disposition Per Ton of Output	Remarks
Lehigh River,		Nesquehoning Creek,		Summit Storage Yard,	L. C. and N. Co.,		Wet,			Spring water,	Water used in loading, drains to Nesquehoning Creek.		Storage yard of L. C. and N. Co. Breaker abandoned.
Lehigh River,		Nesquehoning Creek,		Nesquehoning,	L. C. and N. Co.,	820,504	Wet,	3,500	1,686,420	Nesquehoning Creek and mine water.	Mine and waste water direct to Nesquehoning Creek. Slush to slush bank, draining to Nesquehoning Creek.	.03210	
Schuylkill River,	68	Tarman's Creek,		Tuscarora openings,	Slattery Bros.,						Mine water to Schuylkill River,		Colliery gone and working abandoned.
Schuylkill River,				Bell,	Gorman and Campion,	31,602	Wet,			Schuylkill River,	Slush runs to slush bank, draining to Schuylkill River. Waste and mine water, direct to Schuylkill River.		
Schuylkill River,	69	Swift Run,		Maryd,	Maryd Coal Co.,	314,202	Wet,		900,000	Big Creek and mine water,	Settling tank and mud elevators, draining to Swift Run.	.01500	
Schuylkill River,	70	Big Creek,		Brockton,	Schuylkill-Lehigh Coal Co.,	27,260					Mine water running to Big Creek,		Breaker idle.
Schuylkill River,	71	Kaska-William Creek,		Kaska-William,	Alliance Coal Co.,	32,170					Mine water running to Kaska-William Creek,		Breaker idle.
Schuylkill River,	72	Silver Creek,		Silver Creek,	P. and R. C. and I. Co.,	458,337	Wet,	1,750	997,200	Mine water,	Waste and mine water direct to Silver Creek. Slush to mud elevator, then to slush bank, drains to Silver Creek.		Waste water very black and carries culm. Slush bank seems to be very efficient.
Schuylkill River,	73	Zacharias Run,		Eagle Hill,	P. and R. C. and I. Co.,	262,312	Wet,	1,000	864,000	Mine water,	Mine water to Zacharias Run. Settling tank mud elevators and then slush bank, drains to Zacharias Run.		Effluent nearly clear.
Schuylkill River,				Lucy R.,	Port Carbon Coal Co.,	10,972	Wet,	500	189,000	Mine water,	Slush to slush bank, draining to Schuylkill River.	.00700	Considerable culm reaches river.
Schuylkill River,	74	Mill Creek,		Middle Lehigh,	Mill Creek Coal Co.,	109,341	Wet,	800	518,400	Mine water,	Waste water to settling tank, draining to Mill Creek. Slush to slush bank, draining to Mill Creek.		
Schuylkill River,		Mill Creek,		Moren,	Dodson Coal Co.,	289,854	Wet,	1,400	945,000	Mine water,	Waste and mine water to storage tank, overflows to Mill Creek. Slush to settling tank, drains to Mill Creek.		
Schuylkill River,		Mill Creek,	Mud Run,	Whip-poor-will,	Crystal Coal Co.,						No drainage,		Breaker abandoned.
Schuylkill River,		Mill Creek,	Wolf Creek,	Spruce Creek Shaft,	Mill Creek Coal Co.,						Mine water to Spruce Creek,		Reopening old mines. Will prepare coal at Middle Lehigh Colliery.
Schuylkill River,		Mill Creek,		New Castle,	Dark Water Coal Co.,	103,999	Wet and dry...		540,000	Mine water,	Mine water to Mill Creek,		New breaker not yet in operation.
Schuylkill River,		Mill Creek,	Little Wolf Creek,	St. Clair,	St. Clair Coal Co.,	337,661	Wet,	1,000	2,160,000	Mine water and Mill Creek,	Settling tanks and a slush bank, draining to Little Wolf Creek.		
Schuylkill River,		Mill Creek,		Mt. Hope,	Mt. Hope Coal Co.,	44,748	Wet,	400	648,000	Mine water and Mill Creek,	Settling tank draining to Little Wolf Creek.		Large amount of culm reaches creek.
Schuylkill River,		Mill Creek,	Forest Creek,	Pine Forest openings,	P. and R. C. and I. Co.,						Mine water to Forest Creek,		Working abandoned.
Schuylkill River,	75	Norwegian Creek,	East Branch,	Howard,	White and Co.,	52,681	Wet,	225	216,000	Mine water,	Waste and mine water drain to E. Branch of Norwegian Creek. Slush to slush bank, drains to E. Branch of Norwegian Creek.		Waste water dirty and carries some culm.
Schuylkill River,		Norwegian Creek,	East Branch,	Wadesville,	P. and R. C. and I. Co.,	325,912	Wet,	1,300	864,000	Mine water,	Slush and waste water run to settling tank and mud elevators, then pumped to slush bank draining to E. Branch of Norwegian Creek.		Effluent from slush bank very good.
Schuylkill River,		Norwegian Creek,	West Branch,	Beachwood openings,	P. and R. C. and I. Co.,						Mine water to West Norwegian Creek,		Coal prepared at Wadesville.
Schuylkill River,	76	West Branch Schuylkill River.		Glendower and Richardson openings.	P. and R. C. and I. Co.,	185,292							Coal from openings prepared at Pine Knot Colliery.
Schuylkill River,		West Branch Schuylkill River.		Anchor Washery,	P. and R. C. and I. Co.,	248					Mine water to West Branch Schuylkill River,		
Schuylkill River,		West Branch Schuylkill River.		Oakdale openings,	P. and R. C. and I. Co.,						Mine water to West Branch Schuylkill River,		
Schuylkill River,		West Branch Schuylkill River.	Buck Run,	Buck Run,	Buck Run Coal Co.,	215,807			216,000	Mine water,	Waste water to settling plant. Slush to slush bank, draining to Buck Run.		
Schuylkill River,		West Branch Schuylkill River.		Thomaston openings,	P. and R. C. and I. Co.,	7,418					Mine water to W. Branch of Schuylkill River,		Coal prepared at Pine Knot Colliery.
Schuylkill River,		West Branch Schuylkill River.		Pine Knot,	P. and R. C. and I. Co.,	268,551	Wet,	1,700	1,000,000	Mine and spring water,	Waste water to slush bank. Slush to slush bank surrounded by rock, and lined with ashes.		
Schuylkill River,		West Branch Schuylkill River.	Butcher Creek,	Juggler,	Butcher Creek Coal Co.,	16,128	Wet,	60	50,000	Mine and spring water,	Waste water and slush to slush banks, draining to Butcher Creek.	.05000	
Schuylkill River,		West Branch Schuylkill River.	Butcher Creek,	Ellsworth,	J. H. Davis Estate,	31,893	Wet,	175		¾ mine water: ¼ spring water.	Waste water and slush to slush bank, drains to creek and mines.		
Schuylkill River,		West Branch Schuylkill River.		Mine Hill Gap openings,	P. and R. C. and I. Co.,						No drainage,		Coal prepared at Pine Knot Colliery.
Schuylkill River,		West Branch Schuylkill River.		Oak Hill,	Oak Hill Coal Co.,	275,248	Wet and dry...	900	486,000	Mine water,	All slush and waste water to settling tank, draining to W. Branch Schuylkill River.	.04000	Large quantity of culm reaching West Branch.
Schuylkill River,		West Branch Schuylkill River.	Minersville Creek,	Pine Hill,	Pine Hill Coal Co.,	342,278	Wet and dry...	300	648,000	Mine water,	Slush is pumped to slush bank, draining to Minersville Creek.		
Schuylkill River,		West Branch Schuylkill River.	Minersville Creek,	Emperor Washery,	Emperor Coal Co.,		Wet,	300		Waste water from Pine Hill Colliery.	Slush is pumped to slush bank, draining to Minersville Creek.		Same slush bank as Pine Hill Colliery.
Schuylkill River,		West Branch Schuylkill River.	Minersville Creek,	Wolf Creek Washery,	Wolf Creek Coal Co.,	12,753					At present no drainage,		Idle.
Schuylkill River,	77	West-West Branch,	Lytle Creek,	Lytle,	Lytle Coal Co.,	287,075	Wet and dry...	1,250	504,000	Mine water,	Waste and mine water run direct to Lytle Creek. Slush runs to settling tanks draining to Lytle Creek.	.00890	
Schuylkill River,		West-West Branch,		Phoenix Park No. 3,	P. and R. C. and I. Co.,	237,238	Wet,	800	540,000	Mine water,	Waste and mine water to W. W. Branch direct. Slush to slush bank, overflowing to W. W. Branch Schuylkill River.		

TABLE No. I—*Continued*

Main Watershed	Creek No.	Tributary	Branch	Colliery	Company	Tonnage for 1913 As Returned to the Department of Mines	Process Wet or Dry	Daily Wet Tonnage	Number Gallons Water per 9 Hr. Day	Source of Supply	Disposition of Water	Cost of Dispasition per Ton of Output	Remarks
Schuylkill River, ...	.....	West-West Branch, ...	.....	John Veith openings, ...	P. and R. C. and I. Co., ...	44,368	.....	.....	.....	.....	Mine water direct to W. W. Branch of Schuylkill River.	.....	Coal taken to Otto Colliery.
Schuylkill River, ...	78	Muddy Branch, ...	.....	Otto, ...	P. and R. C. and I. Co., ...	346,137	Wet, ...	1,100	656,740	Mine water, ...	Settling tank draining to Muddy Branch.	.....	
Schuylkill River, ...	79	Little Schuylkill, ...	Panther Creek, ...	Lansford No. 4 openings, ...	L. C. and N. Co., ...	.....	.....	.....	.....	.....	Mine water is main source of Panther Creek.	.....	Coal prepared at No. 5 and 6 Collieries.
Schuylkill River, ...	.....	Little Schuylkill, ...	Panther Creek, ...	Lansford No. 5 and 6, ...	L. C. and N. Co., ...	944,783	Wet, ...	3,600	1,963,440	Mine water, ...	Waste and mine water direct to Panther Creek. Slush pumped to slush bank, draining to Panther Creek.	.02210	
Schuylkill River, ...	.....	Little Schuylkill, ...	Panther Creek, ...	No. 9 openings, ...	L. C. and N. Co., ...	.....	.....	.....	.....	.....	Mine water to Panther Creek.	.....	
Schuylkill River, ...	.....	Little Schuylkill, ...	Panther Creek, ...	Coaldale No. 8, ...	L. C. and N. Co., ...	852,774	Wet, ...	3,000	1,715,680	Panther Creek and mine water.	Waste and mine water run direct to Panther Creek. Slush runs to slush bank, drains to Panther Creek.	.01910	
Schuylkill River, ...	.....	Little Schuylkill, ...	Panther Creek, ...	Coaldale No. 12 Washery, ...	L. C. and N. Co., ...	187,642	Wet, ...	1,100	364,600	Panther Creek, ...	Slush and waste water to slush banks, draining to Panther Creek.	.00590	
Schuylkill River, ...	.....	Little Schuylkill, ...	Panther Creek, ...	Greenwood No. 15 Washery, ...	L. C. and N. Co., ...	166,088	Wet, ...	900	335,340	Mine water and Panther Creek.	Some waste and mine water direct to Panther Creek. Slush to mud elevators and settling tank, then slush bank.	.02460	
Schuylkill River, ...	.....	Little Schuylkill, ...	Panther Creek, ...	Greenwood No. 10, ...	L. C. and N. Co., ...	473,597	Wet, ...	2,300	1,001,160	Mine water and Panther Creek.	Waste and mine water direct to Panther Creek. Slush to settling tank, mud elevator and then to slush bank.	.02460	Same slush bank as No. 12 and No. 15.
Schuylkill River, ...	.....	Little Schuylkill, ...	Panther Creek, ...	Rahn No. 11, ...	L. C. and N. Co., ...	317,469	Dry, ...	.....	721,140	.....	Mine water pumped to Deep Hollow Creek.	.....	
Schuylkill River, ...	.....	Little Schuylkill, ...	Panther Creek, ...	Tamaqua, ...	L. C. and N. Co., ...	346,368	Wet, ...	1,800	743,580	Mine water, ...	Waste and mine water direct to Panther Creek. Slush runs to slush bank, draining to Panther Creek.	.02120	Considerable culm reaches Panther Creek.
Schuylkill River, ...	.....	Little Schuylkill, ...	Wabash Creek, ...	Newkirk (abandoned), ...	.....	.....	.....	.....	.....	.....	Mine water direct to Wabash Creek.	.....	
Schuylkill River, ...	.....	Little Schuylkill, ...	.....	East Lehigh, ...	East Lehigh Coal Co., ...	44,667	Wet, ...	250	498,000	Little Schuylkill River.	All slush, waste and mine water direct to Little Schuylkill River.	.....	Large quantity of culm reaches Little Schuylkill River.
					Grand total tonnage, ...	80,823,125	Grand total gallons water, ..	.....	151,837,289				

TABLE No. II.—*Showing Coal Recovery Operations*

Stream	Location	Operator	Equipment	Annual Tonnage	Operating Cost per Ton Delivered	Sale Price per Ton Delivered	Sizes of Coal	Royalties	Consumers
Susquehanna River,	Buttonwood,	The River Coal Co. (almndoned),	Washery, dredges and flats,	.....	.....	.....	Pea and rice,	.....	W. B. Railway Co.
Susquehanna River,	Beach Haven,	L. E. Hess,	1 dredge and 5 flats,	2,074	$0 80 and $1 50	$1 95 and $2 80	Rice and stove,	None,	Manufacturers and farmers.
Susquehanna River,	Almedia,	Ray Hoffman,	1 dredge and 5 flats,	800	.....	$1 25 $1 65 4 00	Rice, buckwheat, stove.	$8.50 a year,	Manufacturers and farmers.
Susquehanna River,	Almedia,	Reese Hoffman,	1 dredge and 5 flats,	1,150	85	1 25 1 65 4 00	Rice, buckwheat, stove.	$8.50 a year,	Manufacturers and farmers.
Susquehanna River,	Almedia,	Jesse Hopper,	1 dredge and 5 flats,	350	.....	1 25 1 65 4 00	Rice, buckwheat, stove.	None,	Manufacturers and farmers.
Susquehanna River,	Almedia,	Charles E. Custer,	1 dredge and 3 flats,	1,200	1 25	1 40 4 00	Boiler and stove,	Lease landing,	Manufacturers and farmers.
Susquehanna River,	Espy,	Arthur Sharpless,	2 dredges and 11 flats,	2,620	95	1 30 3 50	Boiler and stove,	None,	Bloomsburg Heating Co.
Susquehanna River,	Bloomsburg,	Reese M. Dawson & Son,	1 dredge and 2 flats,	425	75	1 65 4 00	Boiler and stove,	$25.00 a year,	Manufacturers and farmers.
Susquehanna River,	Bloomsburg,	Jerry Geese,	1 dredge and 5 flats,	1,000	.....	1 65 4 00	Boiler and stove,	$8.50 a year,	Manufacturers and farmers.
Susquehanna River,	Danville,	Alfred Forney,	1 dredge and 2 flats,	900	.....	1 35	Boiler,	None,	Manufacturers and farmers.
Susquehanna River,	Danville,	Charles Forney,	1 dredge and 3 flats,	800	1 10	1 35 3 50	Boiler and stove,	None,	Manufacturers and farmers.
Susquehanna River,	Danville,	Benjamin Simmons,	1 dredge and 2 flats,	400	.....	1 35 3 50	Boiler and stove,	None,	Manufacturers and farmers.
Susquehanna River,	Danville,	John Foust,	1 dredge and 2 flats,	400	.....	1 35 3 50	Boiler and stove,	None,	Manufacturers and farmers.
Susquehanna River,	South Danville,	Francis Steffen,	1 dredge and 3 flats,	1,000	.....	1 35 3 50	Boiler and stove,	None,	Manufacturers and farmers.
Susquehanna River,	Klines Grove,	John W. Snyder,	2 dredges and 5 flats,	1,200	75	1 10 3 75 4 50	Rice, buckwheat, pea.	$25.00 a year,	Manufacturers and farmers.
Susquehanna River,	Northumberland,	R. S. Fletcher,	1 dredge and 3 flats,	800	85	1 10	Boiler,	None,	Susquehanna Converting Co.
Susquehanna River,	Northumberland,	James Ruch,	1 dredge and 1 flat,	350	.....	1 10 3 75 4 50	Rice, buckwheat, pea.	None,	Manufacturers and farmers.
Susquehanna River,	Sunbury,	Foster Moore,	1 dredge and 2 flats,	400	75	1 10 3 75 4 50	Rice, buckwheat, pea.	None,	Sunbury Table Works.
Susquehanna River,	Sunbury,	Harry Shaefer,	1 dredge and 2 flats,	400	80	1 10	Boiler,	None,	Sunbury Table Works.
Susquehanna River,	Sunbury,	Daniel Gangler,	1 dredge and 3 flats,	300	.....	1 10 3 50	Buckwheat and pea,	None,	Susquehanna Converting Co.
On Shamokin Creek,	Sunbury,	Harry Beck,	1 dredge and 2 flats,	500	1 33	1 70	Boiler,	10 cents ton,	Sunbury Water Co.
On Shamokin Creek,	Sunbury,	Allemann & Wolf,	1 dredge and 2 flats,	3,000	.....	1 50	Boiler,	Lease landing,	Sunbury Water Co.
Susquehanna River,	Shamokin Dam,	Correl & Hartman,	3 dredges and 8 flats,	3,000	.....	1 10	Boiler,	None,	Manufacturers.
Susquehanna River,	Shamokin Dam,	Went & Hottenstein,	1 dredge and 3 flats,	1,400	81	1 10	Boiler,	None,	Manufacturers.
Susquehanna River,	Dundower,	Jared & Ed. Witmer,	2 dredges and 6 flats,	850	.....	1 00	Boiler,	On tonnage basis,	Manufacturers.
Susquehanna River,	Herndon,	Quincy Carl,	1 dredge and 2 flats,	450	80	1 00	Boiler,	None,	Manufacturers.
Susquehanna River,	Herndon,	Simon Garret,	1 dredge and 5 flats,	500	75	1 00	Boiler,	None,	Manufacturers.
Susquehanna River,	Port Trevorton,	Perris Reinard,	1 dredge and 3 flats,	400	Not given,	1 00 3 00	Boiler and stove,	Lease landing,	Farmers.
Susquehanna River,	Port Trevorton,	Norman Pickel,	1 dredge and 3 flats,	450	Not given,	1 00 3 00	Boiler and stove,	None,	Farmers.
Susquehanna River,	Port Trevorton,	Harry and Francis Hummel,	2 dredges and 5 flats,	900	Not given,	1 00 3 00	Boiler and stove,	None,	Farmers.
Wiconisco Creek,	Elizabethville,	Swab & Zeigler,	1 dredge and 3 flats,	500	Not given,	1 25	Buckwheat,	On tonnage basis	Manufacturers.
Wiconisco Creek,	Millersburg,	Millersburg Light, Heat and Power Co.,	Pumps and flats,	950	Not given,	.....	Boiler,	None,	Manufacturers.
Susquehanna River,	Clark's Ferry,	H. V. Lukens,	1 dredge and 2 flats,	6,000	Not given,	1 05	Boiler,	$25.00 a year,	Harrisburg Light and Power Co.
Susquehanna River,	Clark's Ferry,	H. E. Lukens,	1 dredge and 3 flats,	6,000	Not given,	1 05	Boiler,	2 cents a ton,	Harrisburg Light and Power Co.
Susquehanna River,	Clark's Ferry,	Zeigler & Liddick,	1 dredge and 2 flats,	6,560	Not given,	1 05	Boiler,	2 cents a ton,	Harrisburg Light and Power Co.
Susquehanna River,	Harrisburg,	Harrisburg River Coal, Sand and Stone Co.,	3 dredges, 3 steamboats, 30 flats,	12,000	70	1 25	Boiler,	Lease landings.	
Susquehanna River,	Harrisburg,	Jacob Weimer,	1 dredge and 4 flats,	5,500	75	85	Boiler,	$50.00 a year.	
Susquehanna River,	Harrisburg,	Harrisburg Light and Power Co.,	3 dredges, 2 steamboats, 20 flats,	25,726	77	.....	Boiler,	None,	Same company.
Susquehanna River,	Harrisburg,	Stroh Bros. & Filling,	2 dredges, 1 steamboat, 16 flats,	5,000	75	85 to 1 25	Boiler,	$75.00 a year,	City and capitol.
Susquehanna River,	Harrisburg,	J. B. Hipple,	3 dredges, 3 steamboats, 20 flats,	15,000	70	1 00 to 1 25	Boiler,	$20.00 a year,	United Electric Co.
Susquehanna River,	Harrisburg,	Santo & Speece,	1 dredge, 1 steamboat, 8 flats,	800	.....	1 25	Boiler,	None,	Manufacturers.
Susquehanna River,	Harrisburg,	F. H. Downey,	3 dredges, 2 steamboats, 16 flats,	20,000	60	75 to 1 25	Boiler	Lease landings,	Penna. Steel Co. and Central Iron and Steel Co.
Susquehanna River,	Steelton,	Coiffer Bros.,	1 dredge, 1 steamboat, 3 flats,	1,000	67	75 to 1 00	Boiler,	Lease landings,	Steelton Water Co.
Susquehanna River,	Steelton,	Strine & Flanagan,	1 dredge, 1 steamboat, 4 flats,	5,500	.....	75 to 90	Boiler,	Lease landings,	Manufacturers.
Susquehanna River,	New Cumberland,	William Hoff,	1 dredge, 5 flats,	2,000	70	85 to 95	Boiler,	None,	Manufacturers.
Susquehanna River,	Highspire,	Abraham Lescher,	1 dredge, 1 steamboat, 6 flats,	8,000	65	75	Boiler,	Lease landing,	Penna. Steel Co.
Susquehanna River,	Highspire,	Abner Hoff,	1 dredge, 1 steamboat, 4 flats,	5,500	67	75	Boiler,	Lease landing,	Penna. Steel Co.
Susquehanna River,	Columbia,	Patrick Moriarty,	1 dredge, 1 steamboat, 4 flats,	110	95	1 00	Boiler,	Lease landing,	Manufacturers.
Schuylkill River,	Schuylkill Haven,	Harry Baker,	1 dredge and flats,	850	Not known,	Sale not given,	Boiler and stove,	None,	Manufacturers and farmers.
Schuylkill River,	Schuylkill Haven,	Schuylkill Haven Drifted Coal Co.,	1 dredge and flats,	3,000	Not known,	Sale not given,	Rice and buckwheat	None,	Manufacturers and farmers.
Schuylkill River,	Schuylkill Haven,	Petry & Bowen,	1 dredge and flats,	750	Not known,	Sale not given,	Buckwheat and pea,	Lease landing,	Manufacturers and farmers.
Schuylkill River,	Landingville,	Samuel Shoener & Son,	1 dredge and flats,	4,000	Not known,	Sale not given,	Rice, buckwheat, pea.	4 cents a ton,	Manufacturers and farmers.
Schuylkill River,	Landingville,	C. Arthur Fisher,	1 dredge and flats,	6,000	Not known,	Sale not given,	Rice, buckwheat, pea.	Lease property,	Manufacturers and farmers.
Schuylkill River,	Landingville,	Alspach & Bowen,	1 dredge and flats,	1,300	Not known,	Sale not given,	Rice, buckwheat, pea.	$25.00 a year,	Manufacturers and farmers.
Schuylkill River,	Auburn,	Louisa Mensch,	1 dredge and flats,	6,000	Not known,	Sale not given,	Rice, buckwheat, pea.	None,	Manufacturers and farmers.
Schuylkill River,	Auburn,	Seltzer & Oswald,	1 dredge and flats,	5,000	Not known,	Sale not given,	Rice, buckwheat, pea.	On tonnage basis,	Manufacturers and farmers.
Schuylkill River,	Auburn,	Delaware Seamless Tube Co.,	1 dredge and flats,	4,500	Not known,	Sale not given,	Boiler,	On tonnage basis,	Same company.
Schuylkill River,	Auburn,	Uriah Mengel,	1 dredge and flats,	3,600	Not known,	$0 95 to $2 25	Rice and pea,	On tonnage basis,	Manufacturers.
Schuylkill River,	Below Auburn,	Nolan Coal Co.,	1 dredge and flats,	3,000	Not known,	.....	Rice and pea,	On tonnage basis,	Manufacturers.
Schuylkill River,	Below Auburn,	Crystal Coal Co.,	1 dredge and flats,	2,500	Not known,	$1 00 for rice,	Rice, buckwheat, pea.	None,	Manufacturers.
Schuylkill River,	Hamburg,	Allemann & Wolf,	1 dredge, 1 steamboat and flats,	4,000	Not known,	.....	Rice, buckwheat, pea.	10 cents a ton,	Manufacturers.
Schuylkill River,	Berne,	A. P. Wertley,	Dredge and flats,	.....	Not known,	.....	Rice, buckwheat, pea.		
Schuylkill River,	Shoemakersville,	Allemann & Wolf,	2 dredges and flats,	4,500	Not known,	$1 25 and $3 50	Rice, buckwheat, pea.	Lease landing,	Manufacturers.
Schuylkill River,	Reading,	Allemann & Ebersole,	2 dredges and flats,	10,000	Not known,	2 75 $3 25 5 00	Rice, buckwheat, pea.	5 cents a ton,	Manufacturers.
Lehigh River,	Mauch Chunk,	F. C. Luther & Co.,	2 dredges and flats,	6,000	Not known,	96	Boiler,	On tonnage basis,	N. J. Zinc Co.
Lehigh River,	Bowmanstown,	Drifted Anthracite Coal Co.,	5 dredges and flats,	42,000	Not known,	96	Boiler,	On tonnage basis,	N. J. Zinc Co.

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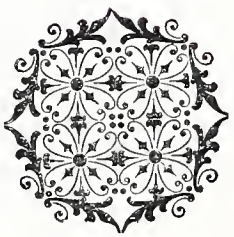

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